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RIVER FLOODS IN GREAT BRITAIN

POTENTIALLY disastrous and fatal situations imposed upon man by Nature in her more violent and extreme moods largely include earthquakes, volcanoes, tornadoes, lightning, fog, tidal flooding and river flooding. Of these, fortunately, earthquake and volcanic activity can be discounted so far as Great Britain is concerned: tornadoes are experienced but rarely (the average is only one per year compared with 143 in America) and they are of limited intensity and duration; lightning is more frequent, but knowledge of the steps necessary to offset its danger is now fairly widespread. While these four phenomena can be quickly dismissed, the last three cannot, for these are the chief 'natural perils' for the inhabitants of these islands; and in each case a situation has arisen during the past twelve months with fatalities which have broken all previous records. The inversion fog which became established over the Thames basin during December 5–8, 1952, trapped four days emission from London factory and domestic chimneys, and the concentrated gaseous pollution plus the water fog was stated to be directly responsible for four thousand deaths and much damage to property. The tidal flooding on the east coast of England at the end of January 1953 caused nearly three hundred deaths and even greater damage to property, agricultural land and livestock; and the Exmoor river floods of August 15, 1952, drowned twenty-eight people, destroyed much of Lynmouth and swept away seventeen bridges.

All these events have naturally shocked the public conscience; but the public reaction has not been consistent. Relief funds were opened for the Lynmouth and east coast flood victims and substantial amounts collected. But no similar action was taken for the even greater London fog disaster. There was also a call for committees to investigate and report upon the problems of tidal flooding and smoke pollution (and active work is in progress). But the Lynmouth disaster was followed only by a local inquiry and did not stimulate any public demand for an investigation and report upon the general problem of river flooding, although this is more frequent in occurrence than either tidal flooding or fog disasters. That strong grounds exist for such an inquiry was made clear at a recent meeting of the Institution of Civil Engineers when the Lynmouth floods were under discussion. With the knowledge now at our disposal, much river flood damage and many fatalities could be avoided by precautionary measures. Without foresight, our increasing population will inevitably spread into potentially dangerous sites, and it can only be a matter of time before the Lynmouth disaster is exceeded.

River flooding occurs in two ways. It may be either periodic or episodic. There may be fairly regular flooding related to a repetitive regime in the life of the river. Winter rains or spring snow melt may produce annual floods, in which case the local inhabitants are fully aware of the need for adapting their way of life to that of the river. Flood-plain sites are avoided when buildings are erected, and

bridges are adapted to maximum known flood conditions. The flood-plain of a maturely developed river may, however, be subject to longer-term inundations, and these have frequently caught unwary house builders and industrial operators, for example, in the Thames valley. Most of the major rivers in the British Isles have a long history of floods which, together with the geomorphological evidence, should provide adequate data for guidance in the proper use of the land. However, local authorities, architects and civil engineers have often failed to take these facts into consideration in the past.

The second type of flooding, exemplified by the Lynmouth disaster, may be regarded as episodic and is related to abnormally heavy storms. The effect of exceptional precipitation may be further intensified by immaturely dissected topography where water is concentrated in narrow valleys with torrential tracts —and devastating effects result. The tiny catchment area of 39 square miles south of Lynmouth yielded a flow in the river that has only been exceeded twice by the River Thames in the past seventy years, although the latter has a catchment area of 3,812 square miles. Flooding of this nature affects an area only at infrequent intervals, and any one incident may pass out of living memory before the next is experienced (Lynmouth's previous recorded flood was in 1796). The local inhabitants therefore may be lulled into a false sense of security as memories of the last serious flood fade into the past.

But over Great Britain as a whole, excessive rain which may lead to this type of flooding occurs with a frequency that is much greater than is generally realized. A fall of three inches of rain in one day is regarded as quite exceptional, and yet in the records in "British Rainfall" one finds dozens of cases from 1865 onwards, and falls of up to nine and a half inches in one day have been reported. Some of these falls have produced a series of historic floods, the most notable of which include the Moray disaster of August 1829; the Bodmin Moor episode of July 16, 1847, when all the bridges but three on the Camel and Inney Rivers were swept away; the Norwich floods of August 25, 1912, which caused great damage to the city; the River Lud (Lincolnshire) disaster of May 29, 1920, when twenty-three fatalities occurred and 1,250 people were rendered homeless; and the Vale of Conway floods of November 1925 when sixteen people were drowned. More recently, there have been the Afon Mawddach floods of May 1944 (not widely reported because of the war-time censorship on weather news); the south-east Scotland floods of August 12, 1948, which resulted in the loss of many bridges, much cattle and extensive damage to property; and finally the Exmoor disaster of August 15, 1952.

These are only some of the more notable episodes in a long and continual story of flooding. Countless other incidents have happened in the past; but with a smaller population fatalities have been fewer. The pressure of an increasing population upon available land space is already acute in these overcrowded islands, the number of towns and villages in valley situations is uncomfortably large and many potentially dangerous flood sites have already been built upon. Without guidance more will follow, and without precautionary measures it can only be a matter of time before another disaster of even greater magnitude than that at Lynmouth overtakes an unsuspecting community. In many areas future building activity, bridge construction, rail and road placements, etc., clearly should be related to the extreme river flood conditions, both periodic and episodic, likely to be experienced in the locality. A synthesis of information is called for from the meteorological records of the past century, earlier historical evidence and also the longer-term geomorphological record: from these data the hydraulic engineer can distinguish potentially dangerous areas. Particular attention should also be paid to those areas outside the spheres of influence of existing river boards—the Lyn, for example, was not a 'designated river'.

The situation touches so many professional interests that a *prima facie* case appears to exist for a committee of inquiry to investigate the problem, to ascertain existing responsibilities and their limitations, to recommend what precautionary measures of flood prevention and control through check dams, afforestation, etc., may be desirable, and to advise what legislative action, if any, should be taken.

KINDLY FRUITS

Science and Fruit

Edited by Prof. T. Wallace and R. W. Marsh. (Commemorating the Jubilee of the Long Ashton Research Station, 1903–1953.) Pp. xiii+308+31 plates. (Bristol: The University, 1953.) 30*s*. net.

LONG ASHTON, now celebrating its jubilee [see p. 273 of this issue], has become a world-famed centre for the scientific investigation of fruit products. Among these, cider reigns supreme. It is therefore fitting that this commemoration volume should deal largely with cider and that it should carry as frontispiece a characteristic portrait of that remarkable Westcountryman, Robert Neville Grenville, whose name was a watchword of agricultural progress at the opening of the twentieth century.

The Long Ashton Research Station arose, indeed, out of cider-making experiments which this genial 'Squire of Butleigh' began in 1893. These led in 1903 to the foundation of the National Fruit and Cider Institute at Long Ashton. This Institute commanded the support of the Board of Agriculture, the Bath and West Society, and the County Councils of Somerset, Devon, Gloucester, Monmouth, Hereford and Worcester. Within the next ten years the Institute became closely associated with the University of Bristol and developed into the Long Ashton Research Station.

The story of this institution, told in detail in the jubilee volume, is one of steady progress and expansion. Its vital importance to the nation became evident during the Second World War, when its staff reached a maximum size of eighty-five members. Brooke-Hunt wrote in 1903: "It is beginning as most things do which really last, in only a small way, but the potentialities are great; and it is hoped that its

career may be one of increasing usefulness, not only in this generation but to others which are to follow". A glance at some of the activities of its first fifty years justifies fully these prophetic words.

In the first place, cider-making has altered out of all recognition since 1903, and has become a highly organized industry. This profound change is due mainly to activities at Long Ashton. In the related field of pomology, embracing the fruit industry in general, much progress has been made in the study of factors controlling vegetative growth, fruiting characters, and quality of fruit. Also in fruit breeding some useful new varieties of pears, plums and black currants have been produced at Long Ashton. As striking examples of work in plant nutrition, 'leaf scorch' has been traced to deficient potassium, and workers at Long Ashton have determined the roles of nitrogen, magnesium, iron, manganese, copper and zinc in English orchards.

Team-work conducted over many years has achieved valuable results in studies relating to plant pathology, entomology and the chemistry of insecticides. Indeed, Long Ashton has become a leading national centre of research on the control of insect pests and plant diseases, in particular through work on sprays and the study of spraying machines and equipment. Contributions to the knowledge of virus diseases of plants have led to the recognition of black currant 'reversion' and strawberry 'crinkle' as such diseases. Other work has been directed towards the domestic preservation of fruit and vegetables and the classification, breeding and control of osier willow varieties for use in basket-making.

Detailed information on these and other activities is given in a series of twenty-two documented contributions made by various authors to this interesting and well-edited volume. One set of papers affords a general review of the work conducted at Long Ashton between 1903 and 1953, and another deals with current work on such problems as plant-growth substances, plant micro-nutrients and recently introduced insecticides and fungicides. The volume also includes a record of names of scientific staff and other officers, Lord Rothschild's Jubilee Lecture, a preface by Captain D. M. Wills, and last but certainly not least a foreword by the Rt. Hon. Sir Winston Churchill, chancellor of the University of Bristol. The book has been admirably produced by that progressive University. The illustrations are well selected as records of historical and scientific development, although artistically one or two of the former show a somewhat large acreage of barren foreground. An index to the book would have been useful.

The historical illustrations of the Butleigh cider team and of various kinds of cider mills and presses give an indication of the antiquity of this ancient and honourable art of cider-making, taking the imagination back to the description in "Vinetum Britannicum" of 1691 by "*J. Worlidge*, Gent." of the "*Ingenio* or *Cider* Mill"; also to some observations of Mistress Celia Fiennes, about 1697, to the effect that "In most parts of Somersetshire . . . they are not curious in the Planting the best sort of fruite. . . . They are likewise as Careless when they make cider—they press all sorts of Apples together . . . They pound their apples, then lay fresh straw on the press, and on that a good lay off Pulp of the apples, then turne in the ends of the straw over it all round and lay fresh straw, then more apples to the top". Here is an early description of "putting up a reed cheese", figured in Plate 8 of the book under notice.

In spite of 'cider sickness', 'ropiness', 'acetification', and other 'disorders of cider', the best of the old-fashioned cidermen of Sutton Montis and other famous centres of bygone days were capable of wringing out a first-class product from their antiquated cider-wrings. Moreover, as T. A. Knight records in his "Treatise on the Culture of the Apple and Pear, and on the Manufacture of Cider and Perry", published at Ludlow in 1797, "the farmers and the peasantry . . . will drink it, and to a most extraordinary excess, when it is really acetous". Doubtless these old cider-drinkers saw a special significance in the pious hope reiterated week after week in the village church by each successive generation: "That it may please Thee to give and preserve to our use the kindly fruits of the earth, so as in due time we may enjoy them". That has been the virtual motto of the institution at Long Ashton throughout the past fifty years. JOHN READ

MOLECULAR THEORY OF FLUIDS

The Molecular Theory of Fluids

By Prof. Herbert S. Green. (Deformation and Flow: Monographs on the Rheological Behaviour of Natural and Synthetic Products.) Pp. viii+264. (Amsterdam: North-Holland Publishing Co., 1952.) 20 f.

THE theory of mechanical properties of materials which possess both elasticity and viscosity has received attention chiefly for the purpose of relating the behaviour of materials in bulk with a mathematical formulation of the rheological properties of a macroscopic element. But the theoretical problem of relating the behaviour of an element with the arrangement and intrinsic properties of the constituent molecules has proved more difficult and is by no means fully explored. In the case of liquids, the molecular theory cannot rely on the simplifying assumption of long-range order appropriate to crystalline solids, or on the assumption of long mean free paths as in the case of rare gases, and the problem is indeed a formidable one. Prof. H. S. Green's assessment of the present position in this field is valuable in directing attention to the mathematical difficulties which arise even when drastic simplifying assumptions are made concerning the properties of a single molecule, and to the important problems which remain unsolved. He shows how a single simplified theory has been developed to explain at least qualitatively all the main features of macroscopic behaviour in molecular terms.

For the most part, the discussion is restricted to non-polar fluids, the mutual molecular interactions being then represented by central forces. Equations expressing viscous and elastic properties, thermal conduction and self-diffusion rates and the conditions for condensation can then be constructed in terms of simple distribution functions. By this means those features of molecular flow are studied which do not depend on the structure of the molecules themselves. This restricted model of a fluid system could not be expected to provide a complete explanation of the observed phenomena, but it does provide a useful first approximation to real liquids. An indication is given of the diffusion effects to be expected when unlike molecules are present, and the consequences of asymmetric and polar molecules are

briefly mentioned. The picture presented, of an assembly of molecules with well-defined positions and velocities, is a classical one, and quantum theoretical considerations are treated only in a final chapter. One feels that this important aspect of the problem could profitably have been discussed at greater length.

The large number of complicated mathematical equations are all well set out and concisely expressed in a specialized notation which is easy to use after a little practice. But the balance struck between the mathematical development of the argument and the physical description of the results does not always leave the reader with a very clear picture of their precise significance for real fluids. Some of the intermediate steps in mathematical arguments which could not be given fully might well have given place to more discussion, with more frequent references to original papers. The book is not an easy one to read, which is no doubt largely due to the inherent difficulty of the subject. It should be very stimulating to the serious student.

J. G. Oldroyd

IMPERFECTIONS IN METALS

Imperfections in Nearly Perfect Crystals

Symposium held at Pocono Manor, October 12–14, 1950. Editorial Committee: W. Shockley (chairman), J. H. Hollomon, R. Maurer, F. Seitz. Sponsored by the Committee on Solids, Division of Physical Sciences, the National Research Council. Pp. xii+490. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1952.) 60*s*. net.

THERE can be only one opinion about this book —that it is, and will for some time remain, a standard work of reference on the subject of imperfections in crystals. It is a report on a conference held in the United States, and, as the list of names of the editorial committee suggests, a galaxy of talent has contributed to it. The list of contributors —twenty in all—is too extensive to be given here, but the standard is exemplified by the first chapter, in which Prof. F. Seitz gives an eminently readable general account of crystal imperfections. He introduces several terms, such as phonons and excitons, which will be new to many people but which will probably come into common use in the future.

The book is divided into four parts: the nature of imperfections; the role of imperfections in deformation; diffusion and related phenomena; and the properties and effects of external and internal surfaces. Seitz's chapter is by far the longest in the book; the rest of the contributors "dot the i's and cross the t's", as it were. As is usual in a symposium, the mode of treatment varies greatly; some chapters are descriptive and others are severely mathematical, but all bear the stamp of authority. The student of theoretical metallurgy is certain to find the book extremely valuable.

For this reason, I would suggest that the title of the book is unwise; it is pedantically correct, but is nevertheless misleading. In the first place, the practical aspects of the work described are almost entirely concerned with metals. It is true that the first chapter is written in general terms, and that there are two other chapters concerned with non-metals, but practically all the other authors make it quite clear that they considered the conference to be one on the metallic state. Secondly, why is the term "nearly perfect" included in the title? Is it usual, for example, to consider a cold-worked powder as nearly perfectly crystalline? Possibly it *is* nearly perfect, since the distortion rarely exceeds 0·1 per cent, but I maintain that the title of the book would not suggest immediately that such a subject is included.

This is an important point. The first contact the potential reader has with a book is in reading the title, and it would be a great pity if the title of this book were to cause it to be overlooked by the theoretical metallurgists of countries outside the United States.

H. Lipson

UNUSED LAND AND HUNGRY PEOPLE

Our Undeveloped World

By L. Dudley Stamp. Pp. 187. (London: Faber and Faber, Ltd., 1953.) 18*s*. net.

THE world's land surface is about 33 thousand million acres; only about 3 thousand million are cultivated: as the world's population is about 2·4 thousand million, this allows only 1·4 acres per head for both food and cash crops. If all this land were devoted to food crops and all gave English yields, a fairly satisfactory dietary would result; but some of the land is used for cash crops and most of it gives yields much lower than ours. Another 5¼ thousand million acres provides some sort of grazing and yields some meat and milk; but large numbers of the world's sheep and cattle furnish neither, and give only wool, hides and tallow. The world's average dietary remains poor.

It has long been the business of agricultural science and practice to seek ways of pushing the area of cultivated land into the grass regions or into the land wholly unused; the fact that 92 per cent of the land surface is uncultivated while millions of people go hungry has been a perpetual challenge that could not be ignored. Prof. Stamp has long studied these unused lands, and also those only partly developed: he summarized his results in the Patten Foundation Lectures given at the University of Indiana in 1950 which were published early in 1952 jointly by the Indiana University Press and the American Geographical Society, and are now re-issued with some additions and rearrangement in this British edition.

He begins with a discussion of the world population, its distribution and rate of increase in the different regions—pointing out incidentally that the increase is most rapid in the Americas, the crude birth-rate of the United States in 1947 being as high as that in India. He then gives a lucid account of the different regions of the world with special reference to their possible value for food production.

The wet tropical regions, in spite of the luxuriance of their forest vegetation, are not really very suitable: their soils are poor and lateritic; the native method of utilization is by shifting cultivation, which served so long as populations were low but is inapplicable when the numbers rise and increase the pressure on the land. As yet no very satisfactory substitute has been worked out, nor have the food crops been properly integrated with the cash crops, and until both sets of problems are solved there can be little further expansion of food production there. In the equatorial lands "the maps suggest that there are at

least a couple of million square miles of underdeveloped or undeveloped land, but the difficulties of bringing them into use are enormous and are likely to remain enormous".

Nor do the tropical savannah regions hold out much greater hope. A considerable amount of scientific work is, however, being done in these regions, and further developments are still possible: the chief difficulties are likely to be the human ones of persuading the natives to accept the steady continuous labour necessary for modern agricultural systems instead of the broken periods with occasional outbursts of heavy work followed by longer stretches of comparative idleness, which suffice for the older methods. Nor does the author see much scope in the northern latitudes. Reference might have been made to the very interesting agricultural developments in Finland, described by Otto Valle in his book "Suomi", which is now available in English.

Prof. Stamp concludes that the middle latitudes offer the best scope for further expansion of food production, and he puts Canada, the United States and the Argentine as capable of considerable development. Undoubtedly they are, as recent events in the first two have shown; some curbing of output may indeed become necessary because of difficulties in selling the produce. But the fall in output from the Argentine also shows the difficulties brought about by political causes. The middle latitudes will probably always produce a physiologically adequate supply of food for their people; but the tropics also score in that they can supply oil seeds and alkaloidal beverages—cocoa, coffee and tea—to the world market.

Great areas of the middle latitudes and their warmer marginal regions suffer from inadequate water supplies, and this is one of the chief factors limiting food production in the world. A few pages only are devoted to this subject: fuller treatment would have been welcome. The author mentions a few irrigation schemes where the natural flow of the river is utilized along its natural course, but not the remarkable modern schemes where the river is actually turned back to the other side of the water-shed, like the Snowy River in Australia which naturally runs uselessly to the sea, but is now being tipped into the dry regions of the Murray system, or the Colorado River in the United States where the head waters are diverted from the Pacific side to the Atlantic side of the water-shed. This new power of diverting rivers may add considerably to the irrigation possibilities of the world—which are at present rather limited.

A later section of the book deals with "salvaging the land", to use the author's expression. As might be expected, he has a good deal to say on this subject and he emphasizes the need for proper land utilization surveys as the basis on which action should be taken. He recognizes the difficulties caused by the widespread poverty of the peasants who form the majority of the food producers of the world. "If," he says, "the millions of cultivators could be *given* fertilizers, and better implements and seed, and instructed in their proper use, they would get better crops with a better yield, build up their own strength and that of their families and their animals and have a surplus for sale—unless the net result of increased production would merely mean the increase of the family and a still larger number of mouths to feed." A simple calculation shows the colossal difficulty of making such a gift; and if made, its effect would certainly be to increase the population and leave the position pretty much as it is now. The author does not pursue this subject: instead he wisely confines himself to the methods by which the Old World can be salved and the New World preserved.

The book is very interesting and deserves study by all who are concerned with land utilization: it brings together much geographical detail not always easily accessible to the agriculturist, and it embodies personal observations by one who has travelled widely in the countries he is describing.

E. John Russell

TECHNIQUES OF RADIOCHEMISTRY

Modern Radiochemical Practice

By Dr. G. B. Cook and Dr. J. F. Duncan. Pp. xx+408+4 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1952.) 42*s*. net.

ONE of the most important of the benefits which have so far been derived from the development of atomic energy lies in the vastly increased availability of artificially radioactive materials; but although workers in many fields of pure and applied science have been quick to apply radioactive tracer methods to the solution of a wide range of problems, there is no doubt that such techniques could with profit find still more extensive application. It is difficult, too, to avoid a suspicion that some of those who turn to a Geiger counter where a previous generation would have used a chemical balance do not always appreciate fully the potentialities of the methods (nor, in some cases, the inherent pitfalls). The present volume, produced by two members of the staff of the Atomic Energy Research Establishment, Harwell, should go far in the provision of encouragement for the faint-hearted and authoritative guidance for those who wish to venture deeper into the borderland between chemistry and nuclear physics.

The greater part of the book is devoted to an exposition of the nuclear physical principles upon which radiochemistry is based: the laws of radioactive decay, the nature of the various nuclear radiations and the techniques for their measurement, and various aspects of radio-isotope production. Sources of errors in counting measurements are discussed at some length, and a chapter is included dealing with health precautions and laboratory design. The treatment is biased throughout towards the practical aspects of the subject, and this tendency is reinforced by the provision of detailed instructions for thirty typical radiochemical experiments, most of which can be performed with quite modest equipment. This outline of a practical course would make an ideal basis for inclusion in a university honours course in chemistry, and will clearly be of great value to those, already graduated, who wish to embark for the first time upon radiochemical work.

Although the more physical techniques are quite adequately covered, comparatively little is said about the associated chemical procedures; one would welcome, for example, a critical assessment of methods for carbon-14 assay and, perhaps, some discussion of the micro-methods which have been developed for the synthesis of compounds labelled with carbon-14. This would, perhaps, have been a better use for some of the forty pages that are devoted to a comprehensive "table of isotopes",

information which is now so readily available elsewhere that such an extensive table scarcely seems necessary. A few minor blemishes have been noted: for example, inelastic scattering of neutrons can but rarely be an exothermic process (p. 208); increasing the time-constant can scarcely reduce the time of response of a rate-meter (p. 188); and the definitions given (p. 274) for "roentgen-equivalent-physical" and for "roentgen-equivalent-man" are distinctly misleading. None of these points, however, is really fundamental, and the general standard of accuracy is very high.

The production of the book is well up to the standards expected of the Oxford University Press, and the price, although higher than one might have wished, is certainly not unreasonable. The book should have an assured place in the growing literature of radiochemistry and should, moreover, be of considerable use to biologists and others interested in radioactive tracer methods. G. R. Martin

WAVES AND TIDES

Waves and Tides

By R. C. H. Russell and Comdr. D. H. Macmillan. Pp. 348+17 plates. (London: Hutchinson's Scientific and Technical Publications, 1952.) 25*s*. net.

THE connexion between waves and tides, clear enough to the physicist, is apparent also from the practical point of view. The effects of both concern the mariner and harbour engineer and are of interest to the seaside visitor, to whom this book is also addressed. Our knowledge of tides has reached a comparatively advanced stage, largely because of their regular nature and their dependence on known astronomical factors. Although the basic theory of waves was developed more than a century ago, reliable observations were scanty until the outbreak of the Second World War, owing to the difficulties of measuring such irregular phenomena, especially from a ship at sea. War requirements gave an impetus to the development of better measuring instruments, providing more observations which, in turn, have pointed to new theoretical problems.

In this book the subjects of waves and of tides have been treated separately by the two authors. Mr. R. C. H. Russell begins Part 1 by describing the characteristics of ocean waves and outlining the methods by which these have been determined. A concise account is given of the classical theory of waves in deep water, the changes which they undergo on approaching a shore, and the effects of reflexion, refraction and diffraction. The way in which waves are generated by wind has been the subject of recent researches and is still largely an unsolved problem. Turning from the waves themselves to their action in moving material and their effects on structures, the author includes much recent work, particularly on models. One is made aware of how many doubtful points and conflicting ideas there are in this field, and of the need for more research, especially of a fundamental character.

Commander D. H. Macmillan introduces Part 2 with a historical and descriptive account of tides, and then gives an account of the general features of the equilibrium theory. The next chapter is concerned largely with the natural and forced oscillations of bodies of water, and shows how the theory of such oscillations may be combined with the equilibrium theory to explain the features of tides as they actually occur. Subsequent chapters deal with more practical aspects, such as the prediction and recording of tides and tidal streams and the prospects of any large-scale use of tidal power. The short chapter on "Tides and the Weather" touches on a subject which has assumed greater topical interest since the book was published. The disturbance of tidal levels by storm surges and wind effects is one of the outstanding problems of tidal research to-day. An unfortunate number of misprints occur in the equations throughout Part 2, including two in the summary of formulæ on p. 334.

The authors have performed a valuable service in producing a book which presents the results of recent researches on waves and tides against a background of more firmly established knowledge.

K. F. Bowden

FRESHWATER ALGÆ OF ILLINOIS

The Algæ of Illinois

By Lewis Hanford Tiffany and Max Edwin Britton. Pp. xiv+407. (Chicago: University of Chicago Press; London: Cambridge University Press, 1952.) 75*s*. net.

FRESHWATER Algæ have been intensively studied in many parts of the United States during the present century, and the rich and diverse character of this flora has been suitably epitomized in G. M. Smith's "Freshwater Algæ of the United States", now in its second edition. Tiffany and Britton's "Algæ of Illinois" deals with only a single State of the Union, covering an area larger than that of England, and takes the form of a flora with keys for the determination of genera and species and diagnoses and figures of the nearly 1,200 species so far recorded. It thus constitutes a work that is of considerable local value which will serve as a stimulus to those continuing with the task of exploration. For them some reference under each group to standard taxonomic works would have been helpful.

In such a local flora, dealing with a region which is still in many respects quite imperfectly explored, it is inevitable that the representation of different groups is unbalanced. Some, like the Oedogoniales and Zygnemales which have been specially studied in the area concerned, are represented by numerous species; but for others the records are meagre. Thus, large genera like *Chlamydomonas* and *Carteria* are each represented by only a single species, only three species of *Euastrum* and one of *Arthrodesmus* are recorded, while such a widespread epiphyte as *Chamæsiphon* is lacking. This inequality must, of course, detract from the value of the flora to workers in other areas and raises the question whether it is advisable to publish a manifestly incomplete record in so ambitious a form. It is to be regretted that the authors have omitted to give adequate habitat data for most species, since the value of a local flora to those working elsewhere depends largely on the geographical and ecological facts that can be gleaned from it.

The copious and for the most part clear illustrations, grouped in 108 plates, contribute much to the general usefulness of the work. A proportion of the figures are original, some of them of a somewhat diagrammatic type which is not always very informative, as, for example, those depicting *Phacotus lenticularis*.

F. E. Fritsch

Le diamant

Histoire, cristallographie, performances esthétiques, taille, gisements, prospection, essai de reproduction synthétique, origine naturelle. Par Edmond Bruet. (Bibliothèque scientifique.) Pp. 256+8 plates. (Paris: Libr. Payot, 1952.) 800 francs.

As the sub-titles indicate, Edmond Bruet's new book, "Le diamant", makes no pretence to deal with the physical properties of the mineral, on which so much research has been carried out in recent years. The author is a geophysicist, and is primarily interested in the occurrence of diamond and in the art of diamond prospecting. The most extended treatment is given to the alluvial deposits in the forests of French Equatorial Africa, on which he writes from first-hand knowledge. Much of this will be new to British readers, since these fields, though they yield some 130,000 carats annually, only account for about 1 per cent of the total world production and are in consequence not much talked about. Recovery of diamond in this area is carried out by primitive methods, using native man-power to drill for samples, and crude jigs shaken by hand for washing and concentrating the gravel.

The more productive fields of South Africa, the Congo, etc., are also well described, and there are interesting chapters on the discovery of diamond in the Canyon Diabolo meteorite, and on the still unsolved mystery of its genesis in the rocks. On this subject, it is curious how little attention has been paid to the foreign minerals included in diamond (pyrope, zircon, enstatite, diopside, hæmatite, graphite, mica and quartz), which should provide more significant evidence than do the so-called 'associated' minerals as to the conditions existing when the diamond crystallized. The weakest chapter in the book is that in which methods for identifying the 'satellite' minerals of diamond are given. Here, for example, a list of ten minerals suggested as 'indicators' for use with heavy liquids cover the range 2·07–2·62 only, whereas not one of the minerals to be determined falls within this range.

On the whole, however, the book is interesting and informative; it can be read with profit by anyone who is interested in the recovery of diamond either in theory or in practice. B. W. A.

Electrochemical Data

By Dr. B. E. Conway. Pp. xx+374. (Amsterdam and New York: Elsevier Publishing Co., Ltd.; London: Cleaver-Hume Press, Ltd., 1952.) 55*s*.

In Vol. 2 of "Textbook of Electrochemistry", by Prof. G. Kortüm and Dr. J. O'M. Bockris, was included a chapter of 162 pages, entitled "Tables of Certain Physico-Chemical Properties", which was compiled by Dr. B. E. Conway. He has now expanded this chapter to about twice its original length and issued it as a separate book. In its present form it contains a great wealth of data, including much more than is suggested by the word 'electrochemical' in its narrower sense; for example, it lists many of the properties of solvents, of melts at high temperatures, of double layers at surfaces, and of colloidal systems. References to original sources are included.

Judgment of such a compilation waits upon two criteria: the partly subjective one of what has been included and what omitted; and the objective test of accuracy and reliability as shown in regular use. On the former, the selection seems to me to have been generally sound, though minor exceptions occur; for example, the omission of any data on acid-base indicators, or the devotion of several pages to the Sörensen and Walbum buffer solutions without mention of the much more recent work of the National Bureau of Standards on the standardization of the *p*H scale or even of the British Standards Institution's 1950 publication on this subject. On the latter criterion it is difficult to express an opinion at this stage. Errors and misprints certainly do occur. Some of those noted in the earlier compilation (see *Nature*, **169**, 982; 1952) have been corrected, but not all; and there are others. Row and column headings have been reversed in Table II, 19; tables on pp. 56 and 59 list values for quantities A' and A_f respectively, without making it clear that they are essentially the same quantity and differ only because one is based on older values of the fundamental physical constants and the other on Birge's more recent ones; no temperature is specified for the surface tension data in Table III, 57.

However, these criticisms are rather trivial in relation to the great mass of information provided. The volume will prove very useful not only to electrochemists but also to physical chemists generally.

J. C. Speakman

Einführung in die freie Geometrie ebener Kurven

Von Prof. Dr. Louis Locher-Ernst. (Elemente der Mathematik vom höheren Standpunkt aus, Band 1.) Pp. 88. (Basel: Verlag Birkhäuser, 1952.) 12.50 francs.

This little book is unique of its kind; it gives an account of a branch of geometry hitherto treated only in rather inaccessible original papers. Although it was more than a hundred years ago that von Staudt and Möbius showed the possibility of studying plane curves by what may be called ultra-pure methods, without the use of co-ordinates, of any metrical considerations, and even of cross-ratios, these methods are still little known. The most important developments of the subjects were made by C. Juel, published in 1913–15 in a Danish scientific journal. Now at last Prof. L. Locher-Ernst has provided an accessible account of the subject, written in a style which makes it very easy to follow. Starting from a simple set of axioms and definitions, he obtains a great number of results; for example, all possible forms of curves of the third order and third class. He also discusses double points, cusps and double tangents. It appears that many properties usually supposed to be typical of algebraic curves are really quite independent of algebraic or analytical considerations, since they are shared by the much wider class of curves considered here. There are 168 diagrams, 28 problems and an index of axioms and theorems. The book should be carefully studied by every geometer. H. T. H. Piaggio

Biological Staining Methods

By George T. Gurr. Fifth edition. Pp. vii+88+4 plates. (London: George T. Gurr, Ltd., 1952.) 5*s*.

In this, the fifth edition, the author has set out to cater for the investigator and technician who may have to discover appropriate methods for staining his biological materials. Formulæ and methods for staining a wide range of materials, involving the use of more than a hundred and fifty stains, are given, the results obtainable being illustrated by some colour photomicrographs. While a comprehensive general index is given at the end, the book would probably be improved by a short table of contents at the beginning. This valuable little manual may be commended both to general and specialist workers.

HIGHER TECHNOLOGICAL EDUCATION

By Prof. J. F. BAKER, O.B.E.
Department of Engineering, University of Cambridge

ONE of the liveliest discussions at the Congress of the Universities of the Commonwealth, held in Cambridge during July 13–17, arose at the meeting on "Higher Technological Education". The opening speakers were Prof. J. F. Baker, head of the Department of Engineering, Cambridge, Dr. K. Venkataraman, director, Department of Chemical Technology, University of Bombay, Prof. J. D. Baxter, director, New South Wales University of Technology, and Sir Roderick Hill, rector of the Imperial College of Science and Technology.

Prof. Baker gave a brief outline of the position of technology in the universities of the United Kingdom. He sketched the completely integrated activities of a typical department, the main interest and responsibility of which is the education of the undergraduate. The three-year undergraduate course concentrates on a grounding in fundamental science and in mathematics with the added discipline of dealing with particular problems in detail. Engineers have a philosophy of their own, and so the teaching must be in the hands of engineers. To remain engineers, teaching officers must engage in applied research, or consulting work of the right standing, which keeps them in intimate contact with industry. When their research has established their school as the leading authority in a particular field, it must be opened to postgraduate students returning after four or five years industrial experience for an intensive course of instruction. These mature men, who return with practical experience and a knowledge of industrial processes and techniques, are ripe for specialist instruction in the highly skilled operation of applying scientific method to the solution of industrial problems which they could not have appreciated in their undergraduate days. The domestic difficulties facing industry in freeing and paying for these men are great but not insurmountable. If they are not overcome the great pressure of engineering development will lead to a demand for lengthened courses for all undergraduates in which, at great expense, immature minds will be forced into moulds turning out, in the end, technicians and not technologists.

Dr. Venkataraman described the position in India. There the All-India Council for Technical Education, constituted in 1946, recognized the advantages of upgrading and enlarging existing institutions, and as a result large capital and recurring grants were made to fourteen departments or colleges of technology. In spite of this, technological institutions are faced with many problems, particularly the shortage of highly qualified and experienced teachers. The surprising statement was made that India turns out more chemical engineers than does Great Britain—and the output is in excess of the demand. The Ministry of Education has instituted a number of paid apprenticeships; but many more are required and industry must be persuaded to undertake this responsibility and also to support research in the universities, as Imperial Chemical Industries and other firms do in Great Britain. Dr. Venkataraman also made a plea for the encouragement of consulting work in the universities so that the staff can keep in touch with practice.

Prof. Baxter gave a most interesting account of the development and present state of the New South Wales University of Technology, the first of its kind in the British Commonwealth. Founded in 1949, it has already made rapid progress, having been fortunate in collecting a high-grade staff. There is, in the highly industrialized State of New South Wales, with its 65,000 technical students, an open road from the technical colleges to the University. The University of Technology decided, in 1951, to accept responsibility for part-time diploma courses. Two principles are followed: first, that a substantial amount of practical training is included in all courses; and second, that study of the humanities is not neglected. A typical arrangement is to devote to academic studies two twelve-week terms, with a two-week vacation between, leaving half the year free for supervised practical experience. In all courses time is devoted to such subjects as English, history and philosophy during the first two years of a course, while in the third and fourth years the student selects one of these subjects for further study. To the present courses in physics, chemistry and the three main branches of engineering are to be added in the future further specialized engineering courses and such subjects as textiles, rubber, plastics, food technology, industrial ceramics and building science.

Sir Roderick Hill turned to a more philosophical aspect of the problems posed by the advance of technology. He considered how we can escape the unregulated impact of applied science and asked what price the universities must pay for a partnership between it and the familiar academic disciplines. He feels it difficult to reconcile a vocational training with the broader education necessary to equip a man for life, but sees no reason why technological studies should not provide that rigorous intellectual discipline needed to train human excellence. Sir Roderick concluded with a plea that motives other than the need to survive must be put before young people; higher aspirations must be invoked.

The chairman, Dr. H. R. Raikes, vice-chancellor of the University of the Witwatersrand, before inviting general discussion, emphasized the importance of the following points: that technology should remain in the universities; that the courses should deal with fundamentals and be not too long; and that provision should be made for selected students to return eventually for postgraduate instruction.

Dr. A. E. Cameron, president, Nova Scotia Technical College, gave a picture of the position in Canada where eleven institutions cover almost all branches of engineering but naval architecture. The courses are of four years duration, the first two being devoted to science and the humanities and the last two to technology. However, such is the pressure of the science studies that the humanities and social science are assuming a minor role.

Dr. P. Dunsheath, London, stressed the vital necessity of close relations between industry and the

universities, since industry is the controlling factor of modern life. Industry must learn what the universities do and how graduates can be introduced, particularly into small firms. The universities must learn to appreciate the nature and purpose of industry. He pointed out that the cessation of ear-marked grants throws an increased responsibility on the universities, since they must not neglect the needs of industry.

Prof. W. G. Sutton, Witwatersrand, claimed that in the technological field his university has the same aims as Cambridge. He feels that too much respect for research must not be encouraged among students of technology, but that postgraduate courses of instruction are desirable. He ended with a warning to New South Wales that South Africa from bitter experience knows the deficiencies of technological institutions as centres of higher education.

Prof. J. R. Daymond, Natal, in his turn claimed allegiance to the Cambridge aims. The University of Natal encourages students to graduate in science and then to read engineering for two further years. Prof. Daymund, taking more than twice the allowance of time given to other speakers, pleaded eloquently for a broader base to be given to the educational pyramid and for universities to resist the tendency to train in specific skills.

Prof. W. H. Hutt, Cape Town, who stressed the fact that he is not an engineer, expressed entire agreement with the views Prof. Baker expressed in opening the session, and summed up the discussion in the apt phrase, "Let the university teach 'why' and leave life to teach 'how' ".

ACADEMIC MOBILITY IN THE BRITISH COMMONWEALTH

By Sir CHARLES MORRIS
Vice-Chancellor, University of Leeds

AT the recent Congress of Universities of the Commonwealth at Cambridge, at which more than eighty universities and university colleges were represented, there was a lively and most interesting discussion on "Academic Mobility in the Commonwealth". A previous Congress five years ago at Oxford had pressed for vigorous action to be taken to promote interchange of both senior and junior scholars between British countries; and following that Congress the United Kingdom Government made available through the British Council rather more than £30,000, so that a start could be made with the pilot scheme. Under this scheme, provision was made for three categories of scholars: very senior and distinguished people paying short visits on the invitation usually of several universities; professors and other established scholars on leave from their own universities for about a year; and junior scholars able to spend one or two years abroad at the beginning of their professional academic careers. It was clear from the discussion at the Congress that the minds of the universities in other Commonwealth countries have been working along the same lines, and a great deal of progress has been made in many countries.

The British Council scheme clearly covers only a part of the total movement between universities, but its role was recognized to be an extremely valuable one; the Congress showed itself particularly interested in the visits arranged in the first category mentioned above, namely, the short visits of very senior and distinguished people. In the meantime, it was obvious that there are some most desirable developments not covered or certainly not sufficiently covered by any of the arrangements in operation within the Commonwealth—in particular, movement between the universities and university colleges in the Colonial countries and the rest of the Commonwealth, and cross-movement between the 'peripheral' countries of the Commonwealth themselves. On the first point it was announced to the Congress that the United Kingdom Government has now made a fund available to enable similar arrangements to be made with the university institutions of the Colonial countries.

After a lively debate the Congress passed a resolution urging member universities to seek suitable opportunities for approaching their Governments with the request that they should contribute to "a co-operatively administered Commonwealth Interchange Fund". It need not be said that the Congress showed itself well aware of the high desirability of movement between the universities of British countries and of non-British countries, notably the countries of Western Europe and the United States. Tribute was paid especially to the success of the Fulbright scheme.

This was perhaps the most interesting instance of a resolution of the last Congress five years ago being actually brought into force. It was a significant instance. The zeal for promoting movement between universities has greatly increased in the past five years. Many speakers at the Cambridge meeting testified to the great value of interchange of undergraduates and young graduates; and a great deal of thought was given to the well-known problems involved in making it easier for members of the academic staff of a university in one country to move to a permanent appointment in another country. There was no kind of suggestion by anybody that too much importance was being attached to such movement or that the zeal for these developments was getting out of proportion. The only hesitant voices were from those who feared that movement between British and non-British universities might possibly suffer. There is no question that the Congress as a whole was most desirous that this should not be so.

THE UNIVERSITY OF LIVERPOOL (1903–53)

By Sir HENRY COHEN
Professor of Medicine, University of Liverpool

IT is a happy circumstance that this year's meeting in Liverpool of the British Association for the Advancement of Science should coincide with the jubilee of the granting of the Charter to the University of Liverpool. For the story of the University's first fifty years is an enviable record both of notable men of science and of man's successful quest for knowledge. A University College had existed for twenty-one years before full university status was attained, and had been served by many impressive scientific figures, including Oliver Lodge who, after occupying the Lyon Jones chair of physics for nineteen years, had resigned to become the first principal of the University of Birmingham.

Thus at its birth the University already enjoyed a high scientific reputation and on its staff were at least two men of science who in their different fields were pre-eminent. The Liverpool School of Tropical Medicine, the oldest in the world, had been founded by the shipowner, Sir Alfred Jones, in 1898, to serve a pressing local need. Ronald Ross was its first lecturer and he had been appointed in 1902 to the Alfred Jones chair of tropical medicine. Two years later was established the diploma of tropical medicine. Ross's contributions to our knowledge of the malarial parasite, its anopheline transmission, and the effective prevention of malaria had led to a Nobel Prize, and he was in its early days the most renowned of the University's professors. His successors' impressive contributions in related fields reflect his stimulating personality—J. W. W. Stephens on malaria and black-water fever, and Warrington Yorke on the chemotherapy of malaria, trypanosomiasis and kala-azar. To-day the School's interest in chemotherapy continues, and the more fundamental processes which underlie the kidney and liver damage in malaria are being studied.

But since 1895, the George Holt professor of physiology had been Charles Scott Sherrington. He had been appointed to the chair when its earlier occupant, Frank Gotch, the eminent electrophysiologist, left Liverpool to succeed Burdon Sanderson at Oxford. Sherrington was to remain in Liverpool for eighteen years before he, too, left for Oxford. It was here that he published, in 1906, the "Integrative Action of the Nervous System", a classic which has been compared with Harvey's "De motu cordis" and Newton's "Principia". Here he laid those stable foundations of neurology which were to lead to the universal verdict that he was "the most profound student of the nervous system the world has yet known". Sherrington attracted many distinguished students to his Liverpool laboratory, including Harvey Cushing and Fröhlich, and many were trained here who later occupied with distinction chairs of physiology in Great Britain and abroad.

It was not only in tropical medicine that Liverpool's natural opportunities were seized. Among the most distinguished of early British oceanographers was William Herdman, who had occupied the Derby chair of natural history since 1881. He was an authority on the ascidians and gave to the School of Zoology a marine bias which profoundly influenced the work of two of his successors in the chair—W. J. Dakin, whose studies on the morphology of various marine animals and on the marine plankton earned him an international reputation, and J. H. Orton, whose life-long interest was the ecology of the sea-shore and who carried out fundamental work on the oyster. Herdman founded the Marine Biological Station in Port Erin, Isle of Man, both for research and for the training of students. More recently, a station has been opened on Lake Bala in North Wales to study the special problems connected with salmon and freshwater fish. Herdman's contribution to the University went beyond his academic gifts and influence. He and his wife endowed two chairs: in 1916 that of geology in memory of their son who was killed in action, with P. G. H. Boswell as the first occupant, and in 1919 that of oceanography, which Herdman himself occupied for a year. His successor was James Johnstone, a distinguished biologist and a profound thinker whose works reveal a man well ahead of his time in the philosophy and methodology of natural science. The character of this chair changed, however, in 1933 when it was accepted by J. Proudman, who had for fourteen years been professor of applied mathematics in the University. In his new chair he was able to continue his notable researches, in conjunction with the Tidal Institute, which have placed his name foremost among those connected with the theory of tides.

In the early years of this century, expanding interest in the application of the techniques of physics and chemistry to the study of biological phenomena led to the establishment a year before the Charter was granted of the first chair in biochemistry in Britain. Its first occupant was Benjamin Moore, whose contributions to the study of cell membranes was stimulated by his association with F. G. Donnan, but who had wider recognition for his forthright if unorthodox views on the origin of life. He founded, with Whitley, the *Biochemical Journal* which, before it was taken over by the Biochemical Society, was published in Liverpool.

There had been a chair of inorganic chemistry in University College since 1881. Its first holder was J. Campbell Brown, a sound teacher, but whose most fruitful contribution to the advance of chemistry was his bequest to the University for the endowment of a chair of industrial chemistry. This was occupied by T. P. Hilditch for twenty-five years (1926–51), during which time his investigations of neutral fats were so remarkably complete and authoritative that he has earned an unrivalled reputation in this field.

In the year in which the Charter was granted, Sir John Brunner endowed a chair in physical chemistry. This was held by F. G. Donnan for ten years before he left to succeed Sir William Ramsay at University College, London. He impressed his character and interests widely, and the influence of his work on membrane equilibria on Benjamin Moore's researches has earlier been noted. Donnan founded a strong research school. His pupils included A. J. Allmand of Kings, Hugh Taylor of Princeton, and F. A. Freeth of Imperial Chemical Industries. E. C. C. Baly, who had worked with Ramsay, went to Liverpool to succeed Campbell Brown in 1910. He was distinguished in spectroscopy and widely known for his mapping of the emission spectra of rare gases in Ramsay's laboratory. He was a man whose adventurous speculations were criticized adversely because they went beyond the then available techniques; but he stimulated others and has indirectly been responsible for much of our knowledge of photosynthesis and of plastics.

Organic chemistry remained without a chair until 1915, when an endowment enabled Robert Robinson to be appointed the first professor. Here he achieved the synthesis of tropanone and began his monumental work on alkaloids, which was the prelude to an outstandingly brilliant and fruitful contribution to his subject. He was succeeded in 1920 by Ian Heilbron. During his tenure of the chair, which he held until 1933, his major interests were his investigations on provitamin D, on sterols, and on vitamin A, which he was later to follow up with marked success.

In 1935 the University was singularly fortunate in securing James Chadwick to succeed L. R. Wilberforce in the chair of physics. Chadwick, the discoverer of the neutron and a Nobel Laureate, inaugurated work on nuclear physics which was to lead to dramatic developments and provide a notable contribution to our war effort. The present extensive

building developments in nuclear physics stem directly from Chadwick's influence, though he returned to Cambridge in 1948 to become master of Gonville and Caius College.

It would be invidious to mention by name those who still serve the University. Many of them will leave an indelible mark on the history of science and a few will light lamps which will shine as brightly as any which illuminated the first half-century of the University's history. The territory now being covered is extensive. It includes the chemistry of natural products such as insecticides, fish poisons, and antibiotics; the synthesis of anthocyanins and new oxygen-heterocyclic compounds such as the chromonopyrones; studies on vitamin A, detoxication, and carotenoids, and the use of radioactive tracers in biogenesis; contributions to the theory of the solid state, metals and dielectrics; to differential geometry, relativity and cosmology; the phenomena of wakes and the compilation of mathematical tables; nuclear physics; endocrinology; and experimental zoology. Restricted space forbids reference to the related fields—engineering, medical, dental, veterinary and the social sciences—in which this University has made and continues to make a contribution of first-rate importance.

In this brief sketch of the outstanding scientific events in the history of science in the University of Liverpool during the past fifty years, it has been possible to mention only a tithe of the foremost figures and achievements. Also, these jottings have been "written by Time on the memory" of one man. Others may justifiably have painted a picture in different colours, light and perspective. Moreover, the solid contribution of many hundreds of a singularly able and loyal junior staff to the shape and stability of the University has had to remain unrecorded. If there be grave omissions or misplaced emphasis, I will hope with Pliny the Younger that "history however it is written will always please".

LONG ASHTON RESEARCH STATION

JUBILEE CELEBRATIONS*

LONG ASHTON, the second oldest agricultural research station in Britain, began in 1903 as a private foundation—the National Fruit and Cider Institute. The Institute evolved from the pioneer experiments in cider-making carried on at Butleigh Court, Somerset, by Mr. Robert Neville Grenville. His enthusiasm stimulated the Bath and West and Southern Counties Society, in collaboration with the County Councils of Devon, Gloucester, Hereford, Somerset and Monmouth, to establish at Long Ashton an Institute for research and instruction in cider-making and fruit-growing. Thanks mainly to Mr. A. E. Brooke-Hunt, superintending inspector of the Board of Agriculture, the Institute, from its inception, was aided by a small government grant.

The Institute continued independently, under the management of governors nominated by the contributing bodies, until 1912, when it became formally associated with the University of Bristol as one of the research institutes set up at that time by the Board of Agriculture and the Development Commissioners. Under this scheme, the subjects of research at Long Ashton were widened to include all aspects of fruit culture and the control of pests and diseases of fruit crops, and the enlarged Institute was given the name of the Long Ashton Research Station. Its administration became the responsibility of the Agricultural Committee of the University, on which the National Fruit and Cider Institute was given agreed representation. This Committee now includes representatives of the following bodies: Council and Senate of the University, the Governors of the National Fruit and Cider Institute, the Ministry of Agriculture, the contributing counties, and the national associations concerned with the manufacture of cider and fruit juices. Since 1931 the Station has been one of the national research institutes the work of which is co-ordinated by the Agricultural Research Council. The Station's income is now largely derived from grants made to the University by the Ministry of Agriculture and the Agricultural Research Council. The scientific staff at Long Ashton numbers thirty-eight, with forty assistant-scientific and office staff; the Station property covers more than 250 acres.

Research at Long Ashton on cider-making and cider orcharding, started in 1903, has received world-wide recognition and maintains its prominence in the Station's programme. The extension of this work since 1931 to include non-alcoholic fruit juices and syrups has provided the basis for a flourishing new British industry. In fruit culture, the work in growth-regulating substances has been specially noteworthy. Fruit-breeding investigations have produced pear, plum and black-currant varieties of high merit. In pest and disease control the special attention given to spray methods and machinery has made Long Ashton a centre for consultation on spraying problems arising both at home and overseas.

The Station has maintained research and advisory work in willow-growing since 1922 and in domestic food preservation since 1930. The work of this Section has recently been extended to include the preservation of meat and poultry, in addition to that of fruit and vegetables.

The plant-nutrition work at Long Ashton enjoys a world-wide reputation. The discovery in 1924 that a major cause of fruit-tree failures was potash deficiency revolutionized fruit production in England. Since 1939 studies of the nutrition of farm and market-garden crops have been included in this work, and, arising from these, the visual symptoms of mineral deficiencies and excesses on a wide range of crop plants have been defined and published in a colour atlas. In 1952 the group of research workers engaged in these investigations was constituted a special Agricultural Research Council Unit for the study of problems of plant nutrition, with particular reference to the micronutrient elements.

The celebrations of the Station's Jubilee, which were jointly planned by the University of Bristol and the National Fruit and Cider Institute, took place during July 22–23. On July 22, the Jubilee Lecture, entitled "Agricultural Research, 1953", at which the vice-chancellor of the University, Sir Philip Morris, presided, was given in the reception room of the University by Lord Rothschild, chairman of the Agricultural Research Council. In a survey of problems of the organization of agricultural research in Britain, Lord Rothschild pleaded for closer contact between the agricultural research institutes and the industries they serve. Without prejudice to the

* See also p. 264 of this issue.

policy of recruiting outstanding scientists and leaving them to develop their own approach to the long-range problems of agriculture, he advocated the listing of the short-term problems in order of economic importance, with the aim of allotting agricultural research facilities in accordance with national needs. He suggested that a reduction in the number of committees dealing with research and administration would be advantageous.

As examples of achievements of agricultural research in Britain, Lord Rothschild cited the work of the National Institute for Research in Dairying on bacteriophage control in cheese, the success of the Moredun Institute in developing treatments for diseases of farm stock, and the combined operations by Rothamsted, Aberystwyth, the Grassland Research Institute, Jealott's Hill and the Hannah Research Institute in pasture improvement, grass conservation and grass utilization. In referring to the phenoxyacetic acid weed-killers, he gave the estimate that they have, in ten years, already increased British cereal yields by 5 per cent. Dealing with the biological importance of trace elements, he stressed the increases in yield made possible by Prof. T. Wallace's work at Long Ashton. In conclusion, Lord Rothschild described the Long Ashton staff as a happy and productive family.

At a commemorative dinner given by the University in the Great Hall on July 22, the principal speakers were Sir Robert Sinclair (pro-chancellor), Sir Reginald Verdon Smith (chairman of Council), Sir Philip Morris (vice-chancellor), Sir William Slater (secretary of the Agricultural Research Council), Earl Waldegrave (trustee of the Bath and West Society) and the Lord Mayor of Bristol.

The celebrations were continued at the Long Ashton Research Station on July 23, when approximately nine hundred guests of the National Fruit and Cider Institute attended, under the presidency of Captain D. M. Wills, chairman of the National Fruit and Cider Institute and of the Agricultural Committee of the University. After a morning programme including exhibits, demonstrations and plantation tours illustrating the history and present-day activities of the Station, two ceremonies recalled the events of 1903. Near the cider orchard that had been set out under his direction fifty years ago, Prof. B. T. P. Barker, emeritus professor of agricultural biology in the University of Bristol, completed the planting of a tree of Ashton Brown Jersey, a variety that had been found on the Station farm in 1903. In the Station Library, Lord Bledisloe, senior vice-president of the Bath and West Society, unveiled a plaque presented by the Society to commemorate its part in the founding of the Institute and recording the close collaboration between the Society and the Station throughout the fifty-year period.

These ceremonies were followed by addresses by the Right Hon. Sir Thomas Dugdale, Minister of Agriculture, Mr. C. P. Norbury, vice-chairman of the National Fruit and Cider Institute, and Prof. T. Wallace, director of the Station.

Sir Thomas Dugdale cited Long Ashton as an excellent example of the way in which the British agricultural research service has arisen and developed to meet specific needs and problems: the service was not a set plan imposed from above. The success and strength of the Station are the result of the co-operation of all the parties concerned. The Minister emphasized the Government interest in horticulture no less than in agriculture and referred to the friendly relations between Long Ashton and the National Agricultural Advisory Service. He paid tribute to the founders of the Station and to its directors, Profs. Barker and Wallace. He announced that Prof. Wallace, who has given much help to the Agricultural Improvement Council, has now accepted his invitation to become a member of that body.

Finally, the Minister referred to the future policy and needs of the Station. While disclaiming the role of a *deus ex machina* (the Minister had arrived in a nearby field by helicopter) he said that he hoped that Long Ashton will see work in hand next year on its much-needed new glasshouses.

Mr. Christopher Norbury, a leader of the British fruit-growing industry, described Long Ashton as one of the foundation stones on which the industry was built. Its work has made possible increased production per acre and per man, through greater regularity of cropping, the better control of pests and diseases and the solution of problems of fruit tree nutrition. Long Ashton also studies fruit products that are providing new outlets for apples and black currants.

Mr. Norbury paid tribute to the University of Bristol for its part in developing not only Long Ashton but also the Chipping Campden Research Station, the work of which on canning has been so valuable to fruit growers. He welcomed the increased Government support for the agricultural research and advisory services, both of which are of vital importance to our survival as a nation.

Prof. T. Wallace thanked, in particular, the Minister for his presence and gracious speech and the Bath and West Society for the presentation of the plaque, referring specially to two distinguished representatives of the Society—Lord Bledisloe and Sir Charles Miles. He welcomed also Sir John and Lady Russell, Sir Donald and Lady Vandepeer, Sir Alan Hitchman, Sir James Scott Watson, Sir Reginald Franklin, Sir William Slater, Dr. T. Loveday and Dr. H. V. Taylor. Among the representatives of organizations concerned with agriculture and horticulture, Prof. Wallace greeted delegates from the Royal Agricultural Society, the Central Horticultural Committee of the National Farmers' Union, the Royal Horticultural Society and the Farmers' Club.

Commonwealth and other Governments whose representatives were welcomed by the Director included Canada, New Zealand, Australia, South Africa, Pakistan and the Netherlands. Prof. Wallace expressed his appreciation to the growers, cider-makers and business firms for their past help and their support of the Jubilee celebrations.

The research stations (East Malling, John Innes, Rothamsted and others), universities and agricultural colleges were warmly thanked for their participation, and Prof. Wallace made a special reference to the presence of Prof. Barker, who was also celebrating his jubilee of service at the Station.

In conclusion he quoted a slightly modified version of a sentence written by Mr. Brooke-Hunt in 1903 describing the establishment of the National Fruit and Cider Institute: "It began, as most things do that really last, in only a small way, and it has developed naturally in accordance with the needs of the times; its spirit remains young and the potentialities are great; and it is hoped that its career may continue to be one of increasing usefulness, not only to this generation, but to others which are to follow".

R. W. Marsh

THE DEEP SCATTERING LAYER IN THE SEA: ASSOCIATION WITH DENSITY LAYERING

By Dr. H. F. P. HERDMAN
National Institute of Oceanography

THE work planned for the sixth commission of the R.R.S. *Discovery II* during 1950–51 included an extensive echo-sounding programme and, when conditions were suitable, efforts were made to record the phenomenon now generally known as the 'deep scattering layer'. Unfortunately, since a large part of the commission was spent in the Southern Ocean in winter, the sea and wind were often a severe hindrance to echo-sounding when the ship was under way. Nevertheless, it was possible on a number of occasions—even in winter—to record the deep scattering layer in the form hitherto noted by American and French observers[1,2].

Our observations ranged from the Western North Atlantic to the Antarctic, but were mostly made in the Pacific and Indian sectors of the Southern Ocean. In general, the scattering layer echo traces were similar in character to those previously described by most authorities, and the vertical migration of the layer, to which a biological significance has been attached, was noted on several occasions, especially between lat. 30° and 45° S. There were also nights when the layer remained at constant depths ranging from 60 to 110 fathoms (110–201 metres); such constant-depth echoes, however, were noted only in high latitudes, near the ice edge, and in winter.

The depths at which the deep scattering layer was found were nearly always less than those generally recorded, both in the Southern Ocean and in warmer seas. Most of the layers recorded by the *Discovery II* ranged in depth between 90 and 120 fathoms (165 and 219 metres), with only an occasional observation of a recognizable layer at a depth of 180 fathoms (329 metres). The thickness of the layer varied between 20 and 75 fathoms (37 and 137 metres). In connexion with the figures quoted above, it should, however, be noted that the frequency of the Kelvin and Hughes Type *MS*. 21 *E* deep-water echo sounder used in the *Discovery II* was only 10 kc./s., as opposed to frequencies of 18–24 kc./s. normal in American echo-sounding instruments, and with which it would seem that most previous examples of the oceanic deep scattering layer have been recorded. This difference in frequency, with its consequent difference in wave-length of the sound transmitted, may (when the scattering can be attributed to a concentration of marine animals) cause echoes to be received from a different group of animals at another level. Recent work by Hersey, Johnson and Davis[3] tends to confirm this hypothesis.

On certain occasions the sounding records (see Figs. 1 and 2) showed echo markings, at depths near the surface, which appear to differ significantly from most of the previous recordings, being thinner and more sharply defined. They agree closely, however, with recordings made by the R.V. *Ernest Holt* in the Barents Sea in 1951[4].

This type of scattering layer was first noticed during a zig-zag cruise along the Pacific ice edge, made by the *Discovery II* in late November 1950. At a number of stations worked in or near the edge of the pack ice, the echo sounder was run while the ship was stopped, or making only 2–3 knots, and in several instances a recording of a scattering layer or layers was obtained. Fig. 1 shows a section of the echo sounding record taken at one of the stations in this series (No. 2759, in lat 62° 12′ S., long. 172° 12′ W.), when the ship was towing nets in a fairly open lead inside the edge of the pack ice. A preliminary analysis of the plankton samples obtained here does not reveal any particular concentration of animals. The catches were, in other words, normal for the region of the ice edge.

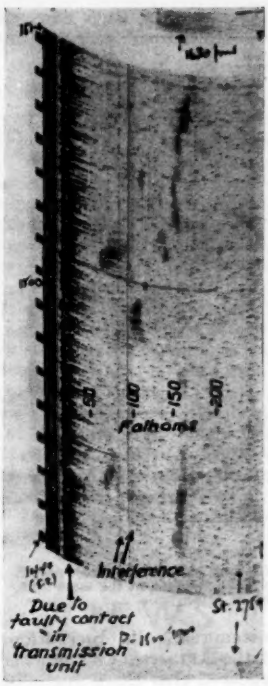

Fig. 1

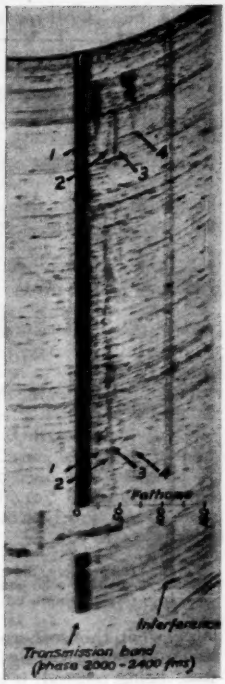

Fig. 2

Fig. 1. Echo record, station 2759 (lat. 62° 12′ S., long. 172° 12′ W.). In lead in pack ice. Soundings, at beginning of record 1,725 fm., at end 1,630 fm. (both depths uncorrected)

Fig. 2. Echo record, station 2775 (lat. 56° 00′ S., long. 153° 35′ E.) Sounding, 1,960 fm. (uncorrected). Multiple echoes recorded during use of bathythermograph marked 1–4 (see also Fig. 3)

Slightly more than three weeks later, in mid-December, observations were being made on the Antarctic Convergence, not far from Macquarie Island. Here, the Antarctic Convergence is, in most seasons, much more sharply defined than in other sectors of the Southern Ocean. The Antarctic Convergence is a continuous natural boundary around Antarctica where the northward-flowing cold Antarctic surface water sinks below the warmer and less-dense sub-Antarctic water, and it can usually be detected by an abrupt change in surface temperature. Below the surface there is an equally detectable boundary between the sinking cold water and the warmer water of the sub-Antarctic region.

At one station in this region (No. 2775, in lat. 56° 00′ S., long. 153° 35′ E.) the echo sounder gave the record shown in Fig. 2. At the time, it was assumed that the multiple echoes represented reflexions from a very diverse scattering layer; but

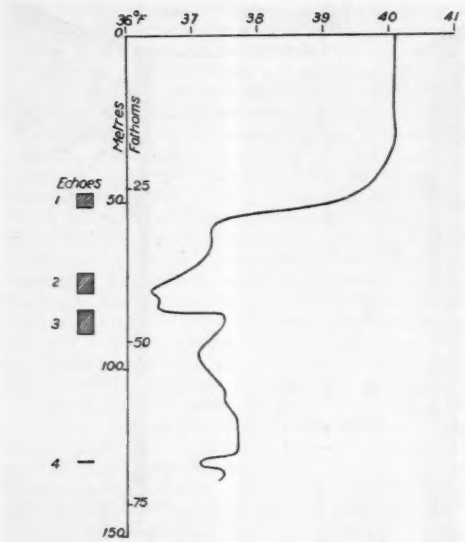

Fig. 3. Temperature, St. 2775, from bathythermograph record. Range of multiple echo layers (1–4), recorded at the same time, shown on left of depth scale

later, when the isotherms comprising the observations taken on this crossing of the Antarctic Convergence were being plotted, it appeared that there might be some correlation between the depths of the multiple echoes and the temperature layering as shown by the bathythermograph. Reference to Fig. 3, where the temperature record has been plotted against depth, and the depth of the various echo layers noted against the latter scale, shows that there appears to be a certain measure of agreement between the depths at which temperature discontinuities occur and those of the various echoes recorded.

A check was then made on the recordings of the scattering layer taken near, or on, the ice edge during the previous month, and at three stations there appeared to be some measure of correlation between temperature discontinuities as recorded by the bathythermograph and scattering layer recordings such as those shown in Fig. 1 (an ice-edge station). The agreement, though not quite so good as that noted on Station 2775, was sufficient to give a clear indication that the presence of the sound scatterers, whether biological or not, can be closely associated with the temperature and density layering. Echo traces almost identical in character to those shown in Fig. 2 have been obtained from a convergence area by the R.V. *Ernest Holt* at several places in the Arctic Ocean where the relatively warm Atlantic water meets cold Arctic water and gives rise to a marked but complicated layering of the water[4]. The correlation of temperature layering, as recorded by the bathythermograph, with the multiple traces on the echo-sounder record, is remarkably good.

Burd and Lee remarked in 1951[5], in summarizing the observations on the deep scattering layer, that no generalizations as to the cause were possible; but the observations since made by the *Discovery II* and the *Ernest Holt* have revealed not only layers which, by their diurnal vertical movement, can be argued to be biological in origin, but also others which are associated with discontinuity in the temperature or density layering. On the other hand, Tchernia[2] has recently stated that no physical discontinuity known at present in oceanographical circles can be invoked to explain the deep scattering layer. The recordings made by the *Discovery II* and the *Ernest Holt* as widely apart as the Arctic and Antarctic seas would, however, seem to show that there can be some connexion between the origin of at least one form of the deep scattering layer and physical discontinuities. Whether this connexion depends entirely on the purely physical boundaries, or on possible concentrations of falling detritus or animal life, checked in their fall by a sudden change in density, is at the moment a matter for conjecture.

[1] Diets, R. S., *J. Mar. Res.*, **7**, No. 3, 430 (1948). Hersey, J. B., and Moore, H. B., *Trans. Amer. Geophys. Union*, **29**, No. 3, 341 (1948).
[2] Tchernia, P., *Bull. d'Inf. du Com. Centr. d'Oceanogr.*, IVme Année, No. 10 (1952).
[3] Hersey, J. B., Johnson, H. R., and Davis, L. C., *J. Mar. Res.*, 11, No. 1, 1 (1952).
[4] Trout, G. C., *et al.*, *Nature*, **170**, 71 (1952).
[5] Burd, A. C., and Lee, A. J., *Nature*, **167**, 624 (1951).

OBITUARIES

Prof. J. B. Dale

John Borthwick Dale, formerly assistant professor of mathematics at King's College, London, died on July 1, aged eighty-two. He was born on June 3, 1871, the eldest son of James F. Dale, a cabinet maker in Great George Street, Liverpool. He had a brilliant career at the High School of the Liverpool Institute (1880–90), and was elected in December 1889 to a foundation scholarship at St. John's College, Cambridge. He won prizes there, including the Wright's Prize and the Sir John Herschel Prize for astronomy in 1892; he was sixth Wrangler in the Mathematical Tripos of 1893, and obtained a first class (Div. 3) in Part II in 1894.

In 1894 Dale was brought on to the mathematical staff at King's College, London, by Prof. W. H. H. Hudson as a temporary assistant lecturer to fill an unexpected vacancy.

A year later he was joined by R. W. K. Edwards, father of the present rector of Aberdeen University, and these two, with Hudson, constituted the entire staff of their department at that time. In 1898 their salaries were raised from £120 to £150 a year, and in October 1902 they were each given the title of lecturer. When, in December 1903, S. A. F. White (see *Nature*, **167**, 259; 1951) was elected to the chair of mathematics, Dale was given the rank of assistant professor, which he held until his retirement in 1936. He married in 1902 Agnes Smith Taunt, of Chelsea, who died in 1924, and in 1931 Mary Lindsay Gladstone, of Rock Ferry, Cheshire, who survives him.

Dale was known chiefly for his "Five-Figure Tables of Mathematical Functions", which were first published by Edward Arnold in 1903 and ran to several editions, the last appearing in 1949. They held a unique position at the time of their appearance and for many years afterwards.

He also compiled "Logarithmic and Trigonometric Tables to Five Places of Decimals", published by Arnold's in 1905 and running to twelve impressions before a new edition came out in 1947. He collaborated with Prof. G. M. Minchin in producing "Mathematical Drawing", issued by the same publishers in 1906. He had some ten papers to his credit, chiefly in *Nature*, *Astr. Nach.* and *Mon. Not.*

Roy. Astro. Soc., his interest being mainly in astronomy, though he published a paper on "The Dissipation of Energy by Electric Currents" (*Proc. Roy. Soc.*, **70**). A treatise on differential equations, in preparation in 1912, was never finished.

Many generations of students still recall Dale as a first-rate teacher. Problems were solved with a satisfying completeness; no untidy ends were ever left in a lecture; and his sentences were delivered in a sonorous voice, as of one speaking *ex cathedra*. Not even the second-year engineers, to whom he lectured regularly, could throw him off his balance. Once, when lecturing on hydromechanics, he said, "We now proceed to consider pitching and rolling". From a back bench came an agonized cry of "Steward!" "We are not concerned with the internal stresses and strains of the passengers", said Dale in his even voice, and went straight on with the lecture. He was always human and practical, and ready to adapt the presentation of his subject to the class before him.

After retirement Dale went to live near Chalfont St. Giles, where he remained until his death. The War made country life much more strenuous than it had been, but until he had a major operation in the winter of 1949–50 he scarcely knew what illness was. Even after this, he recovered a good deal of his strength until his last illness overtook him a few weeks before his death. J. T. COMBRIDGE

W. R. B. Battle

WALTER RAVENHILL BROWN BATTLE was drowned on July 13, in a glacier stream on Baffin Island.

"Ben" Battle, as he was known to his many friends, was born in Leeds on December 23, 1919. He was educated there and took a degree in geography at the University of Leeds. He became a keen traveller and mountaineer, and in 1948 organized and led a four-man expedition to East Greenland, where he made geomorphological and glaciological investigations on Pasterzebreen. Battle returned to the same area in 1949 and afterwards went to Cambridge as a research student to investigate the action of frost and water in the formation of cirques. During this period he twice visited Jotunheimen in Norway with parties from Cambridge. Towards the end of 1952 he went to McGill University and continued his studies as Senior Carnegie Fellow of the Arctic Institute of North America. At the time of his death he was working on Penny Highland, Cumberland Peninsula, with a party from the Arctic Institute. J. D. M. BLYTH

NEWS and VIEWS

Radar Research Establishment, Malvern

As announced by the Minister of Supply in the House of Commons on July 28, the two establishments engaged in radar research in Malvern—the Telecommunications Research Establishment (T.R.E.) and the Radar Research and Development Establishment (R.R.D.E.)—are to be amalgamated, and the new organization will be known as the Radar Research Establishment. The Telecommunications Research Establishment grew out of the Bawdsey Research Station, which was set up in the years just preceding the Second World War specifically for research on radar, a subject of which the existence and possibilities were at that time known only to very few. During the War the Establishment was responsible for the creation of the many radar devices used by the Royal Air Force and, in particular, for the development of microwaves. During the years after the War these new techniques were applied to peacetime problems, including civil aviation and more recently to the new problems of defence, notably the development of guided weapons. In addition, however, a strong physics research group has been built up which has carried out research on a variety of subjects, including the extension of the microwave spectrum to still shorter waves, low-temperature physics, semi-conductors and infra-red spectroscopy as well as advanced electronic techniques; much of this work has been published in the scientific journals. The Radar Research and Development Establishment has a much longer history and goes back to a group set up in 1917 to work on searchlights. The new radar techniques were applied during the Second World War to the problems of directing searchlights and more especially to the accurate control of anti-aircraft fire. The Establishment has since then continued to be responsible for the radar needs of the Army, including new developments in guided weapons; some interesting work on galactic and solar radiation at radio wave-lengths has also been carried out. The new Radar Research Establishment will be responsible for research for the Army, Air Force and Fleet Air Arm on defence problems in the fields of radar, guided weapons, etc., and also for fundamental research on new techniques which might lead to a solution of these problems.

Mr. W. J. Richards, C.B.E.

MR. W. J. RICHARDS has been appointed director of the Radar Research Establishment, Malvern (see above), as from September 1. After graduating in engineering at the University of Manchester, having studied under Prof. A. H. Gibson, in 1925 Mr. Richards joined the Royal Aircraft Establishment, Farnborough, where he carried out research, mainly on aircraft instruments. In 1936 he became head of the Instrument Department, a post which he held until 1942, when he became a deputy director of scientific research in the Ministry of Aircraft Production, London. There his work was mainly concerned with aircraft armaments, but in the period immediately after the Second World War he was one of the pioneers in the field of guided weapons and took part in the first British mission on this subject to the United States. In October 1946 Mr. Richards was appointed to his present post as chief superintendent of the Telecommunications Research Establishment.

I.C.I. Dyestuffs Division: Mr. G. S. J. White

MR. G. S. J. WHITE, chief colourist of the Dyestuffs Division of Imperial Chemical Industries, Ltd., has been appointed division director in charge of Technical Service Departments in succession to Dr. F. J. Siddle, who has taken up the post of managing director of the 'Terylene' Council. It is twenty-four years since Mr. White joined Dyestuffs Division's headquarters at Blackley, Manchester. He is a Londoner by birth, and went from the University of

Oxford to the Leather Section of the Dyehouse Department, where he worked for nine years before he took charge of the Application Research Section. In 1942 he was promoted to the position of assistant chief colourist and two years later became head of the Dyehouse Department. During the course of his career, he has travelled widely in India, South America, the United States, Canada, New Zealand, Australia and most of the European countries. Away from business his principal activities are connected with the Society of Dyers and Colourists, of which he is a member of the Council and chairman of the Lancashire Section, and with the Textile Institute, of which he is a Fellow. He has also concerned himself in the affairs of the Manchester College of Technology and recently completed his third year as external examiner in the Textile Chemistry Department.

Agriculture at Leeds: Prof. N. M. Comber

Prof. N. M. Comber, who has been associated with the University of Leeds for more than forty years, retires at the end of the present session with a distinguished record in the service of agricultural science and education. A graduate of the University of London (Royal College of Science), he went to the Department of Agriculture as assistant lecturer in agricultural chemistry in 1913. In 1925 he became professor of agricultural chemistry, and seven years later head of the Department. His work has been notable for important contributions to soil chemistry and his authorship of books on the subject as well as his active interest in and devotion to agricultural education. He has served on the Council of the Royal Institute of Chemistry and the Society of Chemical Industry, and he has been chairman and treasurer of the Agricultural Education Association. Further, he has been chairman of the Yorkshire Branch of the Rural Community Council and done much by his support and encouragement for the young farmers' club movement in Yorkshire. In 1949 he was elected president of Section M (Agriculture) of the British Association; but his address, entitled "Farming Science and Education", was read for him as illness prevented his attendance. He has served on many university committees and on the Agricultural Sub-Committee of the University Grants Committee, and the value of his knowledge and experience will be greatly missed.

Prof. T. L. Bywater

Prof. T. L. Bywater, at present occupying the Strathcona–Fordyce chair of agriculture at the University of Aberdeen, succeeds Prof. Comber as head of the Department, and will be professor of agriculture. He is no stranger to Leeds, as after graduating with first-class honours in agriculture at the University College of North Wales in 1927 and gaining the M.Sc. at Wisconsin University in 1928, he was appointed to the Department of Agriculture as assistant lecturer in agriculture. He became lecturer in 1934, senior lecturer in 1945, and left in 1946 when he accepted the chair at Aberdeen. During the War he was seconded for advisory work to the West Riding Agricultural Executive Committee. He specializes in animal husbandry and has carried out investigations in fat lamb production, pig rearing, sheep crossing and bullock fattening. He will be able to make full use of the new University farm in continuing this work.

The Agricultural Improvement Council

The Agricultural Improvement Council, set up by the Ministry of Agriculture and Fisheries in 1941, has now been reconstituted, having reached the end of a further three-year period of office. A major function of the Council is to keep under review the technical problems affecting the agricultural (including horticultural) industry and to advise the Minister on the need or otherwise for research and investigation for their solution. The newly constituted Council has now a somewhat wider responsibility, and it includes in its orbit the study of estate management problems covering both farm buildings and other forms of fixed equipment. Before work on a problem can be undertaken it must be clearly defined and its importance assessed; this the Council achieves through one or other of its several committees. It is also an equally important function of the Council to ensure that the agricultural community shall be acquainted as rapidly as possible with the results of research after they have been tested on a scale large enough to warrant their introduction to the practising farmer.

The work of the Council is aligned on one hand with that of the Agricultural Research Council, to the notice of which it brings matters requiring research attention, and on the other with that of the Agricultural Advisory Services, to which it looks for answers to those other problems that can best be solved on commercial farms and experimental stations and through which it puts over the results of research to the farmer.

The membership of the Council, which includes farmers, land-owners, men of science and others, is as follows: Sir Alan Hitchman (*chairman*), Sir Edward Salisbury (*vice-chairman*), Prof. F. Blakemore, Harold Collison, Sir Frank Engledow, H. R. Finn, Frank Griffith, T. Neame, the Duke of Northumberland, H. J. Rathbone, F. Rayns, Prof. Ellis J. Roberts, Prof. H. G. Sanders, F. A. Secrett, Sir William Slater, H. Cole Tinsley, Sir James Turner, Prof. T. Wallace and W. Morley Davies (*secretary*).

The Commonwealth Bureau of Pastures and Field Crops

The Commonwealth Bureau of Pastures and Field Crops, which has been attached to the Welsh Plant Breeding Station, Aberystwyth, for the past twenty-four years, will be transferred to Hurley, Berkshire, in August 1953, where it will be attached to the Grassland Research Station, of which Dr. W. Davies is director. This Bureau, one of the ten Commonwealth agricultural bureaux, was founded at Aberystwyth in 1929, its first consultant director being Prof. (now Sir) George Stapledon. For the first twenty years of its existence the Bureau was in charge of Dr. R. O. Whyte, who was succeeded as director in 1949 by Mr. A. G. G. Hill, formerly director of the East African Agricultural Research Institute, Amani. The Bureau issues the well-known quarterly abstract journals *Herbage Abstracts* and *Field Crop Abstracts*, in addition to its other activities.

Medical Research Council: Applied Psychology Research Unit

Dr. N. H. Mackworth has been appointed director of the Medical Research Council's Applied Psychology Research Unit, at Cambridge, as from October 1. He succeeds Sir Frederic Bartlett, who directed the Unit in an honorary capacity while

holding the chair of experimental psychology in the University. Dr. Mackworth, a whole-time member of the Council's staff, was formerly assistant director. Under arrangements recently agreed between the University and the Council, the larger part of the Unit's work will in future be done outside the University Department of Experimental Psychology, in accommodation acquired by the Council at 15 Chaucer Road, Cambridge, which will be the official address of the Unit from October 1953; but the association with the Department will be preserved, and some members of the Unit will continue to be accommodated in it. A few former members of the Unit have been detached and will in future work wholly in the Department under the general direction of Prof. O. L. Zangwill, who has succeeded Sir Frederic Bartlett as professor and head of the Department.

British Caribbean Meteorological Service

THE director of the British Caribbean Meteorological Service, the most recently formed weather service within the British Commonwealth, has recently published his first annual report (British Caribbean Meteorological Service. First Annual Report 1952. Pp. 23. (Trinidad: Government Printing Office, 1953.) 24 cents). The service was formed in accordance with recommendations made by a conference representing the local Colonial Governments and H.M. Government in Great Britain which met in January 1951. The director, Mr. W. A. Grinsted, formerly of East Africa, set up his headquarters in Trinidad in November 1951 (see *Nature*, 168, 769; 1951). The service has three main meteorological offices providing weather forecasts for a large area and long-distance aviation route forecasts at Piarco (Trinidad), Palisadoes (Jamaica) and Nassau (Bahamas). The provision of hurricane warnings is a very important part of their work during the hurricane season. These offices were previously in the charge of the British Meteorological Office, many of whose staff are still serving in them on loan to the new organization. Reporting stations are maintained in many of the islands and continental territories from the Bahamas to British Guiana and Barbados to British Honduras. Climatological records are collected at the Headquarters and many inquiries have been answered from them. Our best wishes are extended to the new organization with its heavy responsibilities for the meteorological service of this great area.

Characteristics of Current Types of Photomultipliers

As a detector of light signals the normal photo-cell and valve amplifier is limited by the inherent thermal noise of the coupling resistance and the shot effect of the first valve, so that in the fields of spectroscopy, astronomy and nuclear physics, where a highly sensitive light detector is required, the photomultiplier has recently gained popularity. The survey of current types of photomultipliers which is given in the article by Dr. W. E. Turk, of E.M.I. Research Laboratories, Ltd., Hayes, Middlesex (Photoelectric Spectrometry Group Bulletin, No. 5; pp. 100; October 1952) is therefore very useful. First a brief description is given of the phenomenon of secondary emission and of the basic and early designs of photomultipliers. The characteristics of an ideal tube—for example, a highly photosensitive cathode, wide spectral response, high gain in the multiplier section and a high signal/noise ratio—are then outlined, together with the various corresponding practical requirements. Next, the different commercially available tubes are examined and compared with one another and with the ideal tube. A table, in which is collected the essential data of five Cintel, eight EMI, three Mazda and seven RCA types of photomultipliers, is given, and this should be a valuable and easy guide to the selection of the most appropriate tube for a particular purpose. Finally, some very useful practical comments are made about the various techniques employed to improve the signal/noise ratio, the variation in the dark-current of photomultipliers after storage in the dark, and power supplies for photomultipliers.

Petroleum Consumption in Great Britain during 1951–52

THE Petroleum Information Bureau (29 New Bond Street, London, W.1) has issued a booklet on "Statistics Relating to Consumption and Refinery Production 1951 and 1952" which reveals that the consumption of petroleum products in the United Kingdom still shows an upward trend. The total for all products for 1951 was 16,887,908 tons, and for 1952 17,520,145 tons. Of these, the delivery of motor spirit, industrial spirits (including benzole), white spirit and kerosene, accounted for 1,435,811 tons in 1951 and 1,443,173 tons in 1952. Heavy fuel oils (including refinery consumption) consumed by the inland trade were 6,001,013 and 6,354,269 tons, respectively. Other products include lubricating oils and greases, paraffin wax and scale, propane and butane, bitumen, etc. Indigenous materials made available for distribution (excluding shale and crude oils) amounted during the respective years to 111,862 and 108,899 tons of motor and aviation spirit (by hydrogenation) and 78,996 and 175,493 tons of refined benzole. It is noted that no distribution of motor spirit by low-temperature carbonization was made in the two-year period covered by this statistical analysis.

Spectrophotometric Study of the Shell Star ζ Tauri

A SPECTROPHOTOMETRIC comparison of the shell spectrum of ζ Tauri has been made by Anne B. Underhill, of the Dominion Astrophysical Observatory, Victoria, B.C., from high-dispersion plates in 1948 and 1950, and details of the study have been published by the Observatory (Pub. Dom. Astrophys. Obs., 9, No. 2; 1952. Ottawa: Queen's Printer; 25 cents). It is known from the previous work of Adams, Miss Losh, and Struve and Hynek, that this star shows radial velocity changes which suggest binary motion with a period of 132·91 days, and that secondary irregularities of a variable nature, apparently connected with the shell, are superposed on this motion. After Slettebak had announced in December 1949 that the shell spectrum of the star was unusually strong, many more lines being visible than in 1940 and 1941, it was decided to use moderate- and high-dispersion plates to investigate the change and also to determine the physical properties of the shell, by a comparison of the previous plates of 1938 with those of 1950. In the spectrum of the underlying star were lines of NII, OII, SiIII, AlIII and also HeI and H, for which reason the star has been classified as *B2* or earlier, not *B3* as given by previous authors. The periphery of the underlying star was

found to be rotating with a speed of about 350 km./sec. A list of the shell lines between λ 3896 and λ 4923 is given in the paper, and it is shown that the mean degree of ionization in the shell was less in 1950 than in 1938. The apparent rotational velocity of the shell is 150 km./sec., and, on the assumption of the conservation of angular momentum between the shell and the star, this gives a projected velocity of rotation of the shell of 230 km./sec. The fraction of neutral, once-ionized and twice-ionized iron for a number of temperatures and electron pressures computed by Saha's equation are given, and from a consideration of the data it is shown that in 1938 the shell may be described as a body of gas in thermodynamic equilibrium with $T^{\circ} \sim 9{,}000^{\circ}$ K. and log $P_e \sim 1{\cdot}5$, while in 1950 log $P_e \sim 3$, the temperature remaining practically the same. It was pointed out by Struve in 1938 that this description cannot account for the appearance of HeI λ 3965 in the shell spectrum, which requires that the radiation field be dilute and of a high temperature, but it is shown that these apparently contradictory requirements are reconciled and that the shell is probably confined to an equatorial ring or bulge. The 1949–50 radial-velocity measures of the star and shell show that the star was expanding with respect to the shell for a short time after Slettebak had announced an enhanced shell spectrum in *H.A.C.* 1050. It is suggested that the increase of pressure—probably the cause of the change of ionization observed—was due to the outer layers of the underlying star expanding for a short period and compressing the equatorial bulge.

The Comet of November 1948

A REPRINT from *Science and Culture* (**14**, p. 302) has been circulated by the director of the Solar Physics Observatory, Kodaikanal, and this publication contains a description of the comet of November 1948, with nine photographs taken between November 11 and December 7, 1948. Visual and photographic observations of the comet were made on thirteen days, and on two other days only visual observations were possible. A table lists its spherical co-ordinates between the above dates, and various other details are given with three diagrams. The comet, known as 1948 *l*, made a spectacular appearance during the total eclipse of the sun on November 1, 1948; its perihelion distance was 0·135335 and its orbit was practically parabolic.

Love Waves in Earthquakes

IN the seventh paper of his recent series on surface waves, Yasuo Satô has examined theoretically the travel-time of Love waves (*Bull. Earthquake Res. Inst., Tokyo Univ.*, **30**, Pt. 4, 305; December 1952). The work includes calculations, (1) assuming the focus is in the superficial layer, and (2) assuming the focus is in the lower medium. He obtains equations for (1): $x_c' = (H + E)/[(V_{\text{Love}}/V_s)^2 - 1]^{1/2}$, x_c' being the critical distance where Love waves can first be observed, H the depth of superficial layer, E the depth of the point below the bottom of the superficial layer where the emergent ray—produced backwards—would intersect the vertical through the focus, and V_{Love} and V_s the velocities of the Love and transverse waves respectively in the superficial layer. For (2), $x_c = H/[(V_{\text{Love}}/V_s)^2 - 1]^{1/2}$. Assuming a structure for the upper crust in Japan as determined by T. Matuzawa, the following two sets are obtained: $\rho' = 3{\cdot}4$ gm./cm.^{3}, $\mu' = 68{\cdot}9$ km. gm. sec., $V_s' = 4{\cdot}5$ km./sec.; $\rho = 2{\cdot}7$ gm./cm.^{3}, $\mu = 29{\cdot}4$ km. gm. sec., $V_s = 3{\cdot}3$ km./sec. Satô calculates that the intercept time of a wave with a period of half a minute is about ten seconds, and the critical appearance-distance is about two hundred kilometres. This theoretical result agrees with some unpublished observational facts ascertained by T. Akima using his low-pass filter.

Pythium Parasites of Sitka Spruce Seedlings

FUNGI belonging to the genus *Pythium* are frequently found on the roots of various plants, in circumstances which indicate some degree of parasitism. J. H. Warcup (*Trans. Brit. Mycol. Soc.*, **35**, Part 4, 248; December 1952) has demonstrated that three species were actively parasitic on Sitka spruce seedlings grown on alkaline soil. One species (*P. ultimum*) was indeed found to be naturally abundant in the soil of nurseries in alkaline regions (*p*H 6·8–7·2) and rare or absent in those under more acid conditions (*p*H 5·3–5·5). Symptoms varied from 'damping-off' to a slow foot-rot. Partial sterilization by steam or formalin treatment controlled the disease; the plants, moreover, grew much better after this treatment and were more numerous.

Announcements

MR. H. NORMAN G. ALLEN has been re-elected chairman of Council of the British Internal Combustion Engine Research Association for the current year.

MR. T. O. MUIREADHAIGH, of the Department of Industry and Commerce of the Republic of Ireland, has been appointed chairman of the National Committee for Geodesy and Geophysics in succession to Mr. J. C. B. MacCarthy (*Nature* of July 25, p. 142).

WELLCOME Pharmaceutical Research Fellowships, of an annual value of £350 each, have been awarded to J. Thomas and G. L. Willey for a second year in both cases. Mr. Thomas will continue, in the Department of Pharmacy of the University of Manchester, his study of the chemical synthesis of biological activity, particularly bactericidal action, of a new series of quaternary ammonium compounds. At the University of Leeds Mr. Willey will continue his research on the possibility of selectivity of action of nicotine-like stimulant compounds.

THE Pharmaceutical Society has awarded its Ransom Fellowship, worth £300 a year for two years, to Mr. Keith Henry Palmer for research, in the Pharmacy Department of the University of Nottingham, on plant chemistry with special reference to the separation of naturally occurring mixtures of alkaloids. The Society's research scholarship, also of £300 a year for two years, has been awarded to Mr. Kenneth Albert Kerridge, for work in the Department of Pharmacy, Chelsea Polytechnic, on the aspects of trace metal chelation in relation to bacteriostasis.

THE English Electric Research Fellowship in Aeronautics, tenable at the College of Aeronautics, Cranfield, has been awarded for the academic year 1953–54 to R. G. Anderson, of the Mathematical Section of the Aircraft Division of the English Electric Co., Ltd., Warton Aerodrome, Preston. The Perring Scholarship for a two-year course at the College, beginning in October this year, has been awarded to A. Coull, a graduate in civil engineering of the University of Aberdeen.

THE SCIENTIFIC AND TECHNICAL WORKER IN ECONOMIC DEVELOPMENT

ONE of the Committees of the British Commonwealth Scientific Conference, held in Canberra and Melbourne during February–March 1952, considered the great demands now being made by the technical assistance plans of the United Nations, including the Economic and Social Council and the Specialized Agencies as well as the Colombo Plan. The Committee was convinced that the provision of scientific and technical man-power for such purposes must be a continuing responsibility, but thought that more permanent effects would result if the countries concerned sent their own carefully selected nominees to appropriate centres for specialized training. It recognized, however, that where urgent action was necessary the dispatch of specialist workers to the less-developed country might be unavoidable.

The Committee was concerned at the confusion which has resulted from the ever-growing and uncoordinated demands for scientific and technical manpower, a matter which had already attracted the attention of the Parliamentary and Scientific Committee, as well as of Political and Economic Planning. On the Committee's recommendation, the Conference adopted a resolution recommending the Standing Committee to arrange for a study of the problems involved in the supply by the British Commonwealth of scientific and technical personnel to help underdeveloped countries. A main purpose of the Conference was to achieve the maximum of scientific co-operation, though it is of course true that, so far as any adverse effect on the research programme of individual countries is concerned, the heavy demand for technical and scientific assistance to underdeveloped countries can only be mitigated by the adoption of some such measures as have been suggested in P E P Broadsheets (cf. *Nature*, **170**, 677; 1952).

Some of the problems involved in this expanded programme for technical assistance were reviewed early this year by Dr. B. J. Bok in an article in *Science* (**117**, 67; 1953), and the broader aspects of the methods and purposes of planning in the promotion of development have since been discussed in a further P E P Broadsheet (No. 351; February 16, 1953). Dr. Bok's article was concerned rather with what was involved in the way of demands for the services of scientific workers by particular requests for technical assistance. He gave as instances that of the Haitian Government's appeal for help in a programme of fish culture to increase the food resources of that country and a similar development in Thailand; the requirements of the project in fundamental education in Thailand which envisages the planning, organization and operation of the first stage of a ten-year plan of educational improvement; the requirements of some short-term industrial assignments in Jugoslavia; and a malaria eradication project in India.

Apart from these illustrations, Dr. Bok considered the difficult problems involved in the selection of experts to which P E P referred in some detail in its earlier broadsheet. Technical skill and competence alone are often insufficient to make a good expert, and Dr. Bok thinks that the selection of United States experts is particularly difficult, partly because the proper organization for finding the experts is lacking in the United States and partly because the expert is not always assured of prompt employment on his return home from a mission lasting two or three years. Frequently the most desirable experts from a technical point of view lack the essential knowledge of social, cultural and political conditions in other parts of the world, necessitating extensive and expensive briefing. While some experts would be required who have made their career by filling in succession various posts within their fields, in the view of the National Research Council committee which has studied these questions, short-term experts are also required. These latter are usually to be found among scientific workers of considerable repute within their fields who are not always able to be away for extended periods.

The National Research Council committee suggested that, apart from adequate briefing, it is essential to define clearly the assignment of such experts before the departure of the mission and that short-term experts are better used within the framework of an established organization rather than as independent consultants. It is also desirable for all major professional societies to assist in finding the right experts for each assignment by setting up special working committees, as has already been done in the engineering profession. International relations committees of other professional societies have not, so far as Dr. Bok was aware, been active in the recruitment of personnel for overseas services.

With regard to the use to be made of the services of scientific and technical experts, these suggestions run on the lines of the recommendations of Political and Economic Planning. Beyond this, they indicate the need for more support and co-operation from individual scientists and their professional societies. The National Research Council's committee suggested that openings be advertised in professional and technical periodicals, and Dr. Bok remarks that in the United States the National Research Council seems to be the ideal organization to co-ordinate the activities in this field of special committees of the professional societies. The success or failure of recruitment for the technical assistance programme, however, depends ultimately on what individual scientific workers are willing to do in support of that programme, and Dr. Bok's final words here are as true for British as for American scientists.

The latest P E P Broadsheet is concerned less with this individual aspect and responsibility than with the collective aspect and the possibility that experience in one area can give useful guidance for pioneering development in another. Each area has its own particular needs and problems; but P E P's study of international development suggests that it is possible to draw up a set of 'working rules' useful to all who are concerned with development, whether it be re-settlement in Indonesia or the proposed hydro-electric project on the Volta River in the Gold Coast. That in itself is encouraging, and the broadsheet has been issued in the hope of eliciting further suggestions and criticism.

On attitudes and objects of development, the Broadsheet points out that ideas about the nature

and purpose of development have changed, and the conception now gaining acceptance includes as an essential feature the improvement of the daily life of the people of the area concerned, whatever the other objects. While development should aim at maximum returns for minimum real cost and with no avoidable destruction of natural resources, increase of physical destruction is not desirable for its own sake but as a means of increasing the well-being of individuals. Long-term development, moreover, is only possible when there is enough determination within the country to push it through and meet and overcome opposition. This can only be secured by leadership within the country to be developed, and while outside agencies or governments will look for this leadership when they are deciding whether to participate in the country's schemes, this factor is one to be weighed by the country's government in selecting from the formidable total of projects that cannot be left to private initiative those to which the resources of the government and also of public authorities can be effectively committed without becoming unwieldy.

The selection of projects, in the view of Political and Economic Planning, has two aspects: choice of projects which make a genuine contribution to well-being, and ultimate selection of those which make the greatest contribution at the least real cost. An adequate survey of the resources, needs and possibilities of an area is an essential safeguard against disappointment and failure; but, even so, there will often be in practice difficult options between benefits to different groups in a country or between a smaller benefit early as against a greater benefit later. Moreover, the many factors which should be considered as a single pattern in selecting projects should all be kept in mind at every stage of planning. The results of development and its costs must be interpreted widely, and the costs of upheaval set against the benefits of increased consumption or improved health. Alike in the selection and planning of projects and in their execution, the Broadsheet lays much stress on the human aspects of development. The aim should be, if possible, to make the process of development beneficial as well as the end result. Constructive work can be good in itself, and, in stressing the importance of securing co-operation and cultivating mutual respect, P E P is directing attention to the human and social problems of change which are as challenging and important as the technical difficulties and must be tackled with understanding and vision by whatever forms of organization or administration are established to further particular development projects.

SCIENCE IN THE UNITED STATES

THE British Commonwealth Scientific Office (North America), which has been established in Washington, D.C., since the autumn of 1944, is the outcome of the scientific mission under the leadership of Sir Henry Tizard that was sent to Washington in 1940 to facilitate the exchange of scientific and technical information between the Governments of the United Kingdom and the United States. This mission continued throughout the Second World War, being known in turn as the British Technical Mission, the Central Scientific Office, the British Central Scientific Office, and (when, following the successive establishment of separate scientific offices in Washington by New Zealand, Australia and, finally, in September 1944, Canada, the British Commonwealth Scientific Office was established) the United Kingdom Scientific Mission. When the British Commonwealth Scientific Conference met in London in 1946, the value of the Office was already recognized, and the Governments concerned were asked to make suitable arrangements for its continuance as a necessary element in the permanent machinery for scientific liaison. About this time, moreover, the emphasis in the work of the Office was changing from military applications to scientific problems arising from the particular economic and industrial needs experienced by each Mission's own country. The Missions still found, however, that they shared many interests and that the collaboration built up during the War could be profitably continued.

The Office now includes the United Kingdom Scientific Mission and Liaison Offices for Canada, Australia, New Zealand and South Africa. Each Mission is independent and is responsible only to its own Government. They co-operate wherever it is to their mutual advantage, sharing office premises and services, but there is no director: the head of each Mission takes it in turn to act as chairman of a house committee which meets monthly and settles affairs of mutual interest and the operation of common services.

The development of the Office is described in the preface to the "BCSO Review of Science in U.S.A. for the Year ending June 1952", which has recently been published*. Although the first to be published, it is the fifth in a series of such annual reviews and brings together much information of interest to the scientist and technologist in Great Britain which is not always readily available or at best widely scattered. There are references to all the major reports dealing with research and development published in the United States during the year under review so that, as a guide to such source material and the comparison of trends in the United States and the United Kingdom, this review should be sure of a warm welcome, and it is to be hoped that its publication will be continued.

The review begins with a general analysis of the growth and distribution of research and development in the United States. During the past decade this has increased by about 270 per cent and, whereas in 1941 only about 7 per cent of the work in industrial and university laboratories received Federal support, in 1952 this figure is estimated at 39 per cent and the Federal Government now pays for 56 per cent of all United States research and development activities: for 1952–53, this is estimated at 1,640 million dollars out of 2,930 million. Some 91,000 science and technology graduates, more than half of whom are engineers, are employed by the Federal Government, excluding those working on Government projects operated by outside bodies, and, of this total, 58,000 are estimated to be employed on research projects. Altogether some 71,000 professional persons are estimated to be employed in industrial research and development, together with 41,000 technical and 54,000 non-technical assistants.

Expenditure on research and development in the universities rose from 80 million dollars in 1941 to 280 millions in 1952 and is estimated at 350 millions for 1952–53, of which 90 per cent will be for research

* British Commonwealth Scientific Office, North America. The BCSO Review of Science in U.S.A. for the Year ending June 1952. Pp. iv+40. (London: H.M.S.O., 1953.) 2s. 6d. net.

in the biological and physical sciences, including engineering, and 300 millions of this will come from the Federal Government. This dependence on Federal support as well as the bias towards science and technology is already disturbing educational authorities, who fear that the heavy bias towards applied science will also destroy the balance between applied and pure science in the universities and seriously affect the teaching staff of American universities. Some estimates of the research effort of American universities in terms of man-power are cited for the physical and engineering sciences and for medical research.

The next two sections of the survey summarize the findings of the Paley Commission and other bodies concerned with the conservation of materials, and the position of the National Science Foundation and the work of the Interdepartmental Committee on Scientific Research and Development. There follows a series of brief reports on progress in atomic energy and nuclear physics; building research and techniques; mechanical and production engineering; computing machines; water supply and treatment; chemistry; metallurgy; fuel and power; and the biochemistry of food processing and preservation. Finally, the technical assistance programme of the Mutual Security Agency is described, although with this only the United Kingdom Scientific Mission is concerned. Among new developments referred to in this report are mortars made with polyvinyl acetate emulsions, a new brick, a method by which concrete slabs for upper floors or flat roofs can be cast at ground-level and jacked into position, a novel lathe-cutting tool, a "permionic membrane" for giving potable water from brackish or sea water, a continuous ion-exchange process designed by the Stanford Research Institute, the introduction of butadiene–styrene latex-based paints and the rapidly increasing use of antibiotics in feeding farm animals.

BRITISH COLONIAL WELFARE AND DEVELOPMENT DURING 1952–53

A GLANCE at the "Return of Schemes" made under the Colonial Development and Welfare Acts by the Secretary of State for the Colonies during the period April 1, 1952–March 31, 1953 (Colonial Paper 189. Pp. 26. London: H.M.S.O., June 1953; 1*s.* 3*d.*), reveals the dependence of Colonial research on the funds provided under these Acts and the importance of the legislation contemplated in the 1954–55 session to which the Colonial Secretary, Mr. Oliver Lyttelton, referred in his statement to the House of Commons on June 24. The schemes detailed in the White Paper bring the total commitments for development and welfare schemes under the Acts to £97,662,196, of which £13,889,622 is for the year in question, and for research schemes to £11,710,492, of which £1,087,041 is for the year ended March 31, 1953. Of this, £372,486 is for agriculture, £204,878 for medicine, £204,143 for insecticides, £119,115 for products research (£41,600 of which goes to the Colonial Products Research Council), £47,804 for fisheries, £37,754 for economic research, £31,330 for locust control, £23,293 for tsetse and trypanosomiasis, and £24,088 for social science.

Of the actual research schemes, the largest are £173,380 for the East African Agriculture and Forestry Research Organization, £90,000 for the East African Insecticides Research Unit, £106,597 for the Medical Research Council's Field Research Station at Fajara, Gambia, and £77,515 for the Colonial Microbiological Research Institute at Trinidad. £43,160 goes to rice research in Nigeria, £43,000 to the East African Fisheries Research Organization, £32,935 to the establishment of an Agricultural Research and Experimental Station in Nyasaland, £31,330 to the maintenance of the Anti-Locust Research Centre and its extra-mural work, £29,321 to the East African Institute of Social and Economic Research, £26,450 to the Hot Climate Physiology Unit in Nigeria, £24,000 to malaria research in Trinidad, £19,200 for research into the control of *Stomoxys calcitrans* in Uganda, and £16,900 for fundamental insecticide research at the Silwood Park Station (Imperial College of Science and Technology, London) and at Rothamsted Experimental Station.

Grants of particular scientific interest for development and welfare schemes, apart from those for geodetic, topographical, geological and mineral surveys, include £29,476 for the control of 'sudden death' disease of cloves in Zanzibar, £185,000 for a scholarship scheme for residents in Colonial territories to provide training to qualify for public service, £121,620 to University College, Ibadan, £108,040 for the development of African education, and substantial grants for the improvement or development of roads in Nyasaland (£220,000), Malta (£364,394), North Borneo (£305,900) and British Guiana (£315,416), and for the improvement of water supply or control in British Guiana (£919,481), the Gold Coast (£488,000), Malta (£320,250) and Gambia (£70,000). Of a further £1,230,000 for the Uganda Development Plan, £180,000 is for geology and rural water supplies, £390,000 for education, £120,000 for medical schemes, £150,000 for urban water supplies and £90,000 for agriculture.

UNIVERSITIES' COUNCIL FOR ADULT EDUCATION

REPORT FOR 1951–52

UNLIKE the previous six annual reports of the Universities' Council for Adult Education, the seventh annual report, covering the year 1951–52, attempts to survey the extra-mural work of the constituent universities as a whole*. During the year, the work of University Extra-mural Departments throughout Great Britain further expanded, and the departments in the Council became more closely associated. With the addition of the Universities of Edinburgh, Glasgow and Belfast, the membership of the Council is now twenty-one, and the number of courses and classes conducted was 4,064, as compared with eighteen and 2,067, respectively, during 1945–46. During the 1951–52 session, two committees completed their investigations into the teaching of science and the training of teachers, respectively, while the up-to-date bibliography of adult education and the handlist of current studies in the subject, prepared by the Council's Research and Training Sub-Committee, were published, as a co-operative enterprise, by the National Institute of Adult Education.

* Universities Council for Adult Education. Report on the Year 1591–1952. Pp. 26. (Bristol: W. E. Salt, Hon. Secretary, The University, Bristol, 1953.) n.p.

Apart from its interest in relation to the review of adult education which is now going on, the report records the activities of the last session of the first post-war quinquennium, a period marked by striking advances in extra-mural work; and it appears at a time when further development has received its first check, through economies imposed by the universities themselves. The report is thus of value as a contribution to the stocktaking and reconsideration, in the light of recent experience, of possible lines of development, which are appropriate at the outset of a new quinquennium. The Council suggests that a stage of consolidation has now been reached after the rapid expansion of the post-war years; but it does not expect that consolidation will be possible at the peak of achievement. The warning that checks to the growth of adult education, mechanically applied, may have unforeseen and far-reaching consequences, and that interrupted development cannot be resumed at short notice, is the more impressive for the restraint with which it is expressed.

Nevertheless, the report points out, the universities of Great Britain are entering upon a period of great difficulty with greater strength in resources and reserves than at any previous terms. Apart from the increase in extra-mural staffs, the improvement in their conditions of service, and the greater support of the departments from their universities, grants from the Ministry of Education have increased from £71,000 in 1938–39 to £265,000 in 1951–52, an increase which reflects the encouragement given to adult education through the application of the principles of the Education Act of 1944. Much has also been due to the interest and encouragement of the Ministry of Education and its officers.

The debate on the scope, purpose and organization of liberal adult education continues unabated, and many of the reports on the session's work are marked by critical examination of the function and contribution of university adult education, having regard to the economic position of Great Britain. Generally the reports indicate an increasing concern with standards of work and an increasing response by the more serious students to the demands made upon them. While every extra-mural department has been paying increasing attention to standards of work, the figures show a slight decline, on averages, from previous levels, and it appears that here, and elsewhere, there is a greater range of performance than usual between the good and the less satisfactory students. Moreover, while the number of classes in Great Britain has greatly increased, the average enrolment in classes has decreased, and it appears to be more difficult to recruit students for long courses of study.

A distinctive feature of liberal adult education in Great Britain has been its rejection of patently utilitarian studies; but there are indications that in certain subjects—notably the social sciences and industrial relations—the offer of a qualification might stimulate demand. Examinations and qualifications, however, are exceptional features of extra-mural work, though, at least in longer courses, serious work is expected of students, and it is a tribute to their zeal that so much should have been done.

As regards present difficulties, the report suggests that conditions of full employment are not conducive to wide interest in adult education among manual workers. While radio and television are probably its strongest rivals, television is not regarded as necessarily harmful to adult class-work. More use could probably be made of both television and sound-broadcasting as supplements to class teaching, and some questioning of the traditional methods of both organization and teaching is reported. There are signs that different approaches are already being made; but the traditional type of course is provided for the kind of student which is the particular concern of the Workers' Educational Association. The tutorial class was originally devised as a preliminary training for 'workers' deprived of any chance of more than merely elementary schooling, who wished to prepare themselves for the discipline of a course of university study. It rapidly became a substitute for both secondary and higher education for all those whose schooling had been restricted, and as such did notable work. It has now also become a course of study for those who have had reasonable educational opportunities, but who wish to take their education further or pursue some particular interest or study under guidance. The report gives no suggestion as to the Council's own views concerning the decisions which should be taken if economy enforces re-orientation or re-organization of extra-mural work. It indicates, however, that the university departments are fully alive to the issues involved, and the figures given in this report and its survey of subjects of study should materially assist an objective appraisal of the scope and functions of extra-mural work and adult education in the new context.

CARNEGIE UNITED KINGDOM TRUST

REPORT FOR 1952

IN spite of continuing restrictions on capital expenditure, the thirty-ninth annual report* of the Carnegie United Kingdom Trust for 1952 reports good progress with several projects which involved building, notably for the rehousing of the Scottish Central Library and the provision or improvement of village halls. A building licence has also been granted for the Cheshire Foundation Home for the Sick, and it is hoped that the erection of a completely new home, specially designed for its purpose, and which may serve as a model for similar social enterprises elsewhere, will now proceed. A licence has also been granted for the boys' home to be provided by the West Ham Central Mission, and work started in November on this experiment with a country home for boys who had been in trouble or were likely to run into it. Grants during the year totalled £112,667, and the Trust work now appears to be proceeding on an adequate scale after the straitened years of the Second World War. In continuance of earlier surveys of juvenile delinquency, the Trustees have appointed Mr. John Mack, Stevenson lecturer in citizenship in the University of Glasgow, to make a survey of agencies active in this field and the difficulties which confront them. Mr. Mack was particularly asked to direct attention to any gaps in existing services and to indicate any effective action the Trustees might take by initiating genuinely pioneer work, whether preventive or remedial. Pending this report, the Trustees have already concluded that their most effective contributions will be found in their traditional field of practical experiment and demonstration.

* Carnegie United Kingdom Trust: Thirty-ninth Annual Report, 1952. Pp. 32. (From the Trust, Dunfermline, Fife.)

While the Trust may plan projects and make specific assignments to selected institutions, it will not make grants to existing institutions in respect of their work as a whole, nor interest itself in purely local projects. The Trustees also conclude that juvenile delinquency is only one aspect of the much wider problem of family welfare. The term 'juvenile delinquency' will no longer be used for describing a special branch of Trust interest; any such schemes will from now onwards be included under "Community Services and Social Welfare".

The Trustees record that the actual expenditure on village halls increased from less than £12,000 in 1951 to more than £17,000 in 1952, and they express the hope that all the promises made, totalling £80,000 in respect of eighty-four schemes, will have been fulfilled before the end of the present quinquennium. Full reports on two experiments in rural case-work, in Oxfordshire and in parts of Northumberland and Durham, indicate the reality and urgency of problems of family welfare in the countryside and the serious lack of co-ordination of effort among the agencies concerned with welfare services. Two schemes in the programme of the Family Welfare Association are still in an early stage; but the work of the Family Service Units has now extended to Birmingham, Leicester, Sheffield and York and in cordial relations with the local authorities concerned.

Under "Education and Youth Services" a start has been made with the Taunton Museum scheme, which is distinguished for the quality of its collections and by the housing of them in a historic building. The Trust has provided £6,000, chiefly for the provision of cases and other display material, while the Pilgrim Trust has granted £3,000 for repairs to the fabric. Proposals for reorganization and improved display at thirteen other local museums have also been approved, and a grant has also been promised to the Outlook Tower Association of Edinburgh for the reorganization of the Scotland Collection in the Outlook Tower. A special and final grant of £7,500 was made to the National Central Library, and good progress was made during the year with the development of the machine designed to enable sighted people to communicate with those who are both blind and deaf. An investigation was also sponsored into the reactions of youthful audiences to films of various types.

INSPECTORATE OF FACTORIES IN GREAT BRITAIN

ANNUAL REPORT FOR 1951

A FEATURE of the annual report of the Chief Inspector of Factories for the year 1951 (Cmd. 8772; London: H.M.S.O., 1953; 6*s.* 6*d.* net) is a brief historical survey of changes in the industrial picture, so far as safety, health and welfare are concerned, during the fifty years since the consolidating Factory and Workshop Act was passed in 1901. Many changes in industrial location have taken place, and road transport has revolutionized the siting of factories, while the ever-increasing use of bicycles, omnibuses and other transport for the journey to work has made it much less essential to have the factory immediately close to the workers' homes. Many small firms have been amalgamated or swallowed up into large combines or have disappeared, but the great bulk of premises under the Act remain small; for example, 90 per cent of the locksmith work in the Black Country is still carried on by small family businesses, only two factories employing more than a thousand and only eleven more than a hundred, most of them employing less than a dozen. Most chain-makers employ less than twenty, and in their works the only step made in mechanization is the substitution of electric for hand blowers.

The number of factories without power has declined continuously from 137,648 in 1901 to 26,464, while those with power are now 212,245 compared with 95,664 in 1901. Mechanization, moreover, has eliminated much of the grinding load of hard dirty work and heavy lifting, and the changed attitude to mechanization is illustrated by the advertisements of a large bakery, which in 1901 claimed that "all bread was made by hand" and in 1951 boasted of bread "not touched by the human hand". The external aspect of factories has changed considerably, as has the composition of the labour force; but a major contribution to the greater cleanliness of to-day has been made by the greater variety of paints available, and the use of vacuum cleaners and of more suitable floorings. The much better illumination of recent years has also been a valuable stimulus to cleanliness and good housekeeping, as have the provisions of the Factories Act, 1937, which made compulsory weekly cleaning and the daily removal of refuse.

All reports agree that improvements in lighting are among the most important benefits of the past fifty years; but although regulations made under the 1901 Act laid down a standard for sanitary accommodation, poor accommodation, badly maintained, is still found in multiple buildings in large towns. Although few local authorities carry out routine inspections, relations with the local authorities appear to be much more friendly than at the beginning of the century. The standards of air space were raised by the Act of 1937 to 400 cu. ft. per person from the 250 cu. ft. of the 1901 Act; but while much remains to be done in regard to process steam, great advances have been made in ventilation, more particularly in the application of local exhaust to remove dangerous dust or fumes. New risks, however, continually arise, and where the sanctions of the general law and voluntary action are insufficient, each new hazard has been dealt with by special regulations. Every year, too, brings fresh reports of improved methods of mitigating or eliminating high temperatures in such trades as laundries, glass works or steel works, and also of improved methods of securing adequately warm temperatures.

Already in 1901, though the steam engine was still the main driving-force in industry, in spite of considerable inroads by the gas engine, inspectors were commenting favourably on the rapid development of electric power; and during the past fifty years all other forms of motive power have gradually declined. The individual drive and the sectionalization of transmission machinery have greatly reduced the dangers from revolving transmission machinery, and during recent years much attention has been given to the spacing or re-spacing of looms. A great deal has been done since 1901 in the provision of guards; but, in spite of the further obligation of the 1937 Act in regard to fencing dangerous machinery, occupiers still complained in 1951 that they were obliged to add to the fencing of many machines. Legal provisions regarding the reporting of accidents have varied during the years so that no valid con-

clusions can be drawn from a comparison of the 1,035 fatal accidents and 82,725 non-fatal accidents in 1901, with the corresponding figures of 944 and 159,693 in 1925 and 828 and 182,616 in 1951. Moreover, inspectors have sought increasingly to foster a positive attitude to accident prevention by stressing the importance of training and organization for safety.

Deaths and serious injuries from works fires, as distinct from burns from local sources, have been rare throughout 1951, and in all trades with special risks to health the records and memories of fifty years show a similar pattern. First there was the gradual, and sometimes grudging, realization of the source of danger to health, powerfully stimulated by the work of the medical inspectors and by individual research carried on by enlightened firms; search was then made for substitutes for the dangerous materials, with experiments in their use and special inquiries, followed, wherever agreement on voluntary action could not be obtained, by prohibition or control by special regulations. New techniques learned by sometimes unwilling management and men brought unexpected success after initial hostility to new materials. Where the dangerous material could not be eliminated, progress has been by way of total enclosure of the plant or by fitting local exhaust ventilation, with special provision of facilities for washing, protective clothing and regular medical examination. In the chemical industry enormous advances have been made in improving atmospheric conditions by exhaust ventilation, condensing plants and dust filtration units; but the increased use of inflammable and toxic solvents in the boot and shoe trades has brought new risks which are not yet completely removed. As a result of the introduction of low-solubility and leadless glazes, for the first time since records were kept there were no cases of lead poisoning in the Stoke district in 1944, and in 1947 the Pottery (Health) Regulations made the use of raw lead glaze illegal.

The biggest improvements in welfare—a word unknown to the 1901 Act and owing its legal existence to welfare orders made under the Police, Factories, etc. (Miscellaneous Provisions), Act of 1916—have come during the past ten years. Canteens were rarely found before 1914, but are now accepted as a necessity by most firms and workers, in spite of complaints, sometimes unjustified, about the quality of the food or service. In the same period has come a strong movement towards all forms of joint consultation, while throughout the half-century the attitude of management generally has greatly changed. Washing facilities were a luxury at the beginning of the century and only became compulsory in all factories under the 1937 Act. Each year since 1945 has recorded increased effort to give sufficient washing accommodation in attractive surroundings; but much less has been done to bring about really first-class cloakroom accommodation. In 1901 also the provision of protective clothing was rare. Now it is increasingly provided by firms as and when the process appears to need such clothing, and overalls are now often provided as a part of the works scheme for good appearance and good discipline. Outside the factory it is increasingly difficult to guess the type of work carried on by persons one meets in the streets.

No feature of the past half-century has been more striking than the reduction of working hours. In 1901 the usual working week was about fifty-five hours in most trades, the 1901 Act allowing sixty hours for women and young persons in non-textile factories, with a twelve-hour period from Monday to Friday and an eight-hour period on Saturdays. The working day in the Midlands and North of England was usually 6 a.m. to 6 p.m., with half an hour for breakfast, one hour for the midday meal and no authorized short breaks. Partly as the result of scientific study of fatigue, from 1918 the forty-eight hour week came to be recognized as normal and received legal sanction as a maximum for women and young persons more than sixteen in the 1937 Act. The five-day week which gained popularity in the 'thirties, particularly in the new industries in the South of England, became almost universal after the Second World War except in a few trades. The harsh asperities of shift-work have also been greatly softened.

At the beginning of 1902 there were ninety-five inspectors, including thirty-eight junior inspectors, and about thirty-four inspectors' assistants, as well as a principal lady inspector and a staff of eight lady inspectors. At the beginning of 1951 there were 322 inspectors and more than fifty vacant posts. The composition of the inspectorate had also changed. In place of the one medical inspector of 1901 there was a senior medical inspector and twelve medical inspectors, while the electrical inspector first appointed in 1902 has now been succeeded by a senior electrical inspector and thirteen electrical inspectors. The one engineering adviser of 1901 was the predecessor of the eighteen inspectors in the present engineering and chemical branches under the senior engineering and the senior chemical inspectors. Prosecutions in 1901 were more numerous but were largely for illegal employment of one kind or another, which does not occur on any scale at present. The basic principles on which inspection has been founded appear to have changed little, and the inspector's main task is still in the factories.

As regards the year 1951, the report expresses the view that the need for economy in the use of power, materials and labour compels a constant striving for greater efficiency which, although not always ensuring higher standards of safety, health and welfare, tends on the whole to improve working conditions. Those points of some general interest which emerge are, first, the establishment of a communal health service in one of the oldest trading estates in England which has assisted a factory manufacturing basic lead carbonate and lead nitrate in improving health conditions. Steps have been taken to equip a laboratory at the London School of Hygiene and Tropical Medicine, as an extension of this side of the health service, and a chemist has been engaged to undertake, *inter alia*, the estimation of lead in samples of air collected by the health engineer. The second matter is the attention given to radiological developments in industry. Special visits to representative factories using X-rays for the radiographic, fluoroscopic or crystallographic examination of castings and other materials have indicated that a very high standard of equipment, installation and use prevails. The question of protection in handling the large services of up to and just over a curie of cobalt-60 now available from Harwell, however, has caused some concern, and although no new permanent applications of radioactive tracers to routine industrial factory processes were reported during the year, it is likely that this new technique will soon be widely applied. The third point is further evidence of the capacity of persons more than sixty years of age to do useful work in industry without increased liability to accident.

THIRD INTERNATIONAL CONGRESS ON GLASS

THE Third International Congress on Glass was held in Venice during June 29–July 2, associated with the International Commission on Glass, the annual meeting of which was held on July 3. 179 delegates attended from twenty countries; they included 65 from Italy and 22 from Great Britain.

The Congress was organized by a Committee of the Italian Glass Manufacturers Federation. At the opening meeting of the Congress, Principe Giovanni Ginori Conti, who is president of the Federation, was inducted as president of the Congress by Dr. B. P. Dudding in his capacity as president of the Second International Congress on Glass held in London and Sheffield in 1936. This ceremony concluded with the presentation to Prince Ginori Conti by Mrs. W. E. S. Turner of a glass goblet on which the coat of arms of the Conti family had been engraved by Mrs. Turner, who is among the best of present-day English engravers.

The first day of the Congress was devoted to lectures on general subjects open to all members attending. Dr. M. Pasquato (Venice) reviewed the history of the glass industry centred in Murano since the eleventh century and traced the influence Venetian traditions have had on the artistic and industrial developments of the glass industry of the world. Prof. W. E. S. Turner (Sheffield) reviewed the growth of societies and research institutions not associated with specific industrial organizations since the formation of the Glass Research Delegacy in Sheffield in 1915 and the Society of Glass Technology in 1916. This was of particular interest to the Italian members, as negotiations have been proceeding between the Government and industry in Italy for some time, and a definite announcement was made at the end of the Congress reporting a decision to form both a technological society and in addition a research institute supported by government and industrial contributions. M. D'Argenlieu (Paris) reviewed the development of the use of glass in the building industry and raised some pertinent questions as to whether the glass industry had exhausted its contribution in this field. Prof. F. Roma (Bologna) described the sources of natural gas in northern Italy and discussed the conditions necessary to the efficient use in the glass industry. Prof. M. Czerny (Frankfurt am Main) indicated recent advances in the understanding of the problems of glass melting, and in particular the relative importance of heat transfer by radiation convection movements in the molten glass and conductivity through the glass. Mr. Edward Meigh (London) dealt with the interrelation of technology and management in modern industry, referring to the nature of the studies made in Great Britain under the auspices of the Institute of Industrial Administration and the British Institute of Management, with which the former is now amalgamated.

The following two days were devoted to specialized papers classified in four groups, three of which met simultaneously: Group I, Chemical and Physical Properties of Glasses; Group II, Glass Manufacture: Materials, Equipment, Methods; Group III, Form, Design, and Decoration of Glass; Group IV, History and Archæology.

About fifty papers were presented, and their efficient discussion was secured by making arrangements under which delegates could hear the speaker in any one of four languages, by a microphone and telephone service, which is becoming a general technique at international conferences.

In Group I several papers were presented which dealt with the modern physical concepts of the structure, and the slow changes which take place with time in the physical properties of glasses, depending on their previous thermal history. Another paper discussed the rate of reaction of glass-forming materials and the influence of the particle-size and the scale of operations on the rate of reaction.

In Group II, important and novel ideas concerning the methods employed to melt glasses and the techniques for exploring new designs of glass-melting furnaces were presented and led to extended discussions.

The artistic and archæological interests of glass brought together artists from eight different countries, and in the course of the discussions the influence of the artist on production of utilitarian glassware was emphasized.

Associated with the Congress were visits to Soc. Venez. Conterie e Cristallerie, Murano, to Vetrocoke at Porto Marghera, together with visits to museums, the Giorgio Cini Foundation on the isle of S. Giorgio Maggiore, and to the hydro-electric plant at Caverna, owned by the Società Adriatica di Elettricità. The Congress closed with a banquet at the Excelsior Palace at the Lido, given by the Associazione Nazionale degli Industriali del Vetro.

At the annual meeting of the International Commission on Glass held on July 3, Dr. B. P. Dudding, honorary secretary of the Commission, was elected president in succession to Prof. W. E. S. Turner, who has been president of the Commission since its formation in 1933. Prof. Turner was elected honorary president of the Commission. M. H. Vandecapelle, director of the Institut National du Verre, Belgium, was elected honorary secretary, and M. G. Henry, director general of the Union des Verreries Mécaniques, Belges, was elected honorary treasurer on the resignation of Dr. W. M. Hampton, of Chance Brothers, Ltd., Birmingham.

A tentative invitation was extended by the Swedish delegate to the Commission to hold its annual meeting in Sweden in 1954. No decision was taken in respect of the next Congress; but it is hoped that it will be held on the Continent in 1956.

ADVANCES IN METHODS OF STUDYING CLAYS

A MEETING of the Clay Minerals Group of the Mineralogical Society, held in the Department of Geology and Mineralogy, Marischal College, Aberdeen, during April 10–11, was mainly devoted to a discussion upon advances in methods of studying clays. On the morning of April 10, the laboratories of the Macaulay Institute for Soil Research and the Chemistry Department of the University were visited by members of the Group. At the scientific sessions the chair was occupied on the afternoon of April 10 by Dr. G. W. Brindley (University of Leeds) and on the following morning by R. H. S. Robertson (Glasgow).

Introducing the discussion, Dr. G. Nagelschmidt (Safety in Mines Establishment, Sheffield) reviewed

the methods currently available for clay investigations, stressing particularly those of recent introduction. Following the course of a sample from its reception to the elucidation of its mineralogical composition, he referred to the following techniques and indicated the present limits to their application: deflocculation, clay mineral separation (for example, use of Clerici solution, sedimentation, electrophoresis, flotation, etc.), chemical analysis, light microscopy (including phase contrast), electron microscopy, X-ray examination, differential thermal analysis and infrared spectroscopy. Since many of these techniques, although at present very useful, are still not fully developed, more research into the basic principles upon which they are established is vital to the development of clay mineralogy.

The interpretation of X-ray diffraction patterns of interstratified minerals was considered theoretically by Dr. D. M. C. MacEwan (Rothamsted Experimental Station, Harpenden). Although previous work had established that curves showing the types of scattering to be expected from various mixtures of layers could be constructed and used for identification purposes[1], under certain circumstances (for example, for polycomponent mixtures, or where segregation occurs), the construction of these curves becomes very laborious. The same applies to the alternative calculation of the appropriate Fourier transform; but by using an approximation, this latter method can, with very little calculation, give the requisite information as to the nature of the interstratified material[2]. Dr. MacEwan, replying to comments by Dr. Nagelschmidt and by Dr. H. P. Rooksby (General Electric Co., Ltd., Wembley), agreed that reflexions to higher angles are necessary to refine the transform, and that there is an analogy to scattering of X-rays by glasses. When R. Greene-Kelly and G. Brown (both of Rothamsted Experimental Station) questioned whether absorption difficulties, etc., would allow the requisite minimum number of orders of the basal spacing to be recognized in the diffraction patterns of, for example, many soil clays, Dr. MacEwan replied that he had as yet had little opportunity to apply the method to these materials.

Two papers from the Safety in Mines Research Establishment, Sheffield, dealt with quantitative X-ray methods. In the first, Dr. R. L. Gordon, O. G. Griffin and Dr. Nagelschmidt defined the criteria for internal standards to be of use in the photographic diffraction method, and demonstrated that both magnesium oxide and boehmite (γ-AlOOH) can be used for quartz. The former is best when large amounts of quartz (more than 30 per cent) are present, but the latter, for the comparison lines used, is not so good in the presence of kaolin. Some applications were described, and the results obtained were compared with those derived from chemical investigations. In the second paper, Dr. Gordon and Mr. Griffin described in detail a Geiger–Müller counter X-ray diffraction apparatus. Accurate measurement of line intensity rather than line position was aimed at, and was achieved by monitoring the primary X-ray beam by an auxiliary Geiger counter. Internal standards are unnecessary where accuracy of ± 10 per cent is adequate. In practice, this method is complementary to the photographic one. In the discussion Dr. Rooksby, Mr. Brown and Mr. Greene-Kelly referred to difficulties which might arise from differential absorption when using internal standards, but Dr. Gordon indicated that in the systems investigated all the minerals had approximately the same absorption coefficient. In reply to a further question by Mr. Brown, Dr. Nagelschmidt stated that, since the materials being investigated did not contain either boehmite or lepidocrocite, the former was a satisfactory internal standard. Dr. Gordon, commenting upon remarks by Dr. Brindley and E. W. Radoslovich (Cavendish Laboratory, Cambridge), stated that for the Geiger counter method a large sample is preferable to a small one, since the latter would entail narrowing the X-ray beam.

New techniques for preparing oriented-aggregate specimens for X-ray examination were reported in two brief papers. W. A. Mitchell (Macaulay Institute) has obtained parallel orientation of platy minerals by mechanical compression of the clay between two flat metal surfaces. The amount of orientation produced and the improvement in orientation for certain specimens over that produced by the conventional method were demonstrated by X-ray photographs. Mr. Brown described a semi-micro method utilizing special 'Perspex' centrifuge tubes with detachable bases, the clay settling on the flat inner surface of the base as an oriented aggregate. By using only about 1 mgm. of clay, the time necessary for preparation of the finished specimen from the original soil could be considerably shortened. In the discussion Mr. Greene-Kelly commented that the pressure technique would be very useful for platy minerals which would not disperse, and Mr. Mitchell reported that orientation had been obtained with soil clays containing only 5–10 per cent of platy minerals. Mlle. M. J. Deudon (I. R. Sidérurgie, Paris) and Dr. Brindley both referred to experiments with pressure, the latter reporting that high mechanical pressure could expel the water from hydrated halloysite and partially collapse the 'tubes'. The possibility of some orientation occurring during preparation of specimens for the Geiger counter X-ray diffraction apparatus, and consequent interference with results, was referred to by Dr. Rooksby.

Of two papers on differential thermal analysis, one dealt with technique and the other with interpretation of results. The apparatus for carrying out the analysis under inert atmospheres was fully described by Prof. A. L. Roberts and Dr. K. Carr (University of Leeds), who found this necessary where bituminous materials were involved, as these were not oxidized by hydrogen peroxide pre-treatment. The use of this modification for the quantitative determination of clay minerals in the presence of coal dust was demonstrated. In discussing the interpretation of the low-temperature endothermic peak of expanding minerals, Mr. Greene-Kelly reviewed previous theories[3] and pointed out their weaknesses. The occurrence of double peaks was shown to be normal where the hydration energy of the cation is sufficiently high for differences in mobility of desorbed water to be fully developed. When the hydration energy is below a certain value the mobility of the more tightly held water is apparently increased and the two peaks merge, as with sodium-, potassium-, rubidium- and cæsium-montmorillonite. In the discussion, the unsatisfactory nature of hydrogen peroxide as an oxidizing agent for organic matter was commented upon by Dr. R. C. Mackenzie (Macaulay Institute) and by D. A. Holdridge (British Ceramic Research Association, Stoke-on-Trent); the former reported the formation from certain soil clays of insoluble oxalates which interfere with thermograms, and the latter suggested the use of organic solvents for removing bituminous

materials. Mr. Holdridge also remarked upon correlation between the size of the low-temperature exothermic peak and the amount of carbon as determined chemically. Dr. B. S. Neumann (Fuller's Earth Union, Redhill) inquired about Prof. Roberts's and Dr. Carr's experience with ferrous compounds in inert atmospheres. Welcoming Mr. Greene-Kelly's theory, Dr. Mackenzie said that the explanation of the previously anomalous Li^+ result is most encouraging. Dr. Brindley and he also referred to the possibility of diffusion being the peak-determining factor for materials other than montmorillonoids—for example, kaolins[4].

Possible methods which could be developed for the separation of clay minerals from mixtures were discussed and assessed by Miss K. R. Farquharson (Macaulay Institute). An attempt to use the reputed hydrophobic character of Deuel's montmorillonite-organic complexes[5] has been unsuccessful. The results of electrophoretic mobility measurements are now being applied using a constant-flow cell. Concentration of one component of a binary mixture has so far been observed, and further work is in progress. To a comment of Mr. Greene-Kelly upon the possibility of sorption of montmorillonite on kaolinite[6] at the *p*H values used (about *p*H 7), Dr. Mackenzie and Miss Farquharson replied that absence of electrolyte is necessary to avoid other undesirable effects. Mr. Robertson suggested that, because of rugosity[7] differences, separations might be possible by centrifugation of very dilute suspensions.

B. D. Mitchell (Macaulay Institute) and Dr. Mackenzie described a completely inorganic method for removing free iron oxide from clays, based upon the use of sodium hydrosulphite ($Na_2S_2O_4$)[8]. The effects of *p*H, time of extraction, etc., upon the efficiency of iron removal and upon the crystal lattice of various clay minerals were assessed, and a comparison made of the constituents brought into solution by this and by various other methods. Replying to I. H. Warren (English Clays, St. Austell), they indicated that neither sulphoxylates nor zinc hydrosulphite have yet been tested. The nomenclature of sodium hydrosulphite was discussed by Mr. Holdridge and Mr. Robertson; of the names hydrosulphite, hyposulphite and dithionite, the last was considered to be probably the least ambiguous. The effect of sodium hydrosulphite upon chlorites was referred to by Mlle. Deudon.

The last three papers, while not on the subject for discussion, demonstrated the results obtainable by current refined techniques. Mr. Brown gave evidence for a new clay mineral—a dioctahedral analogue of vermiculite—in a soil clay. The parent material is a dioctahedral mica. Data for the effect of various ions upon the relative intensities of the various X-ray reflexions were given. In reply to comments by Mr. Warren, Dr. Brindley and Dr. Nagelschmidt, Mr. Brown stated that the mineral reacted with ammonium ions after hydrogen peroxide treatment. Although five clay minerals were present, he considered all the reflexions described belonged to one mineral. W. A. Mitchell compared the weathering data with those for the formation of trioctahedral vermiculite in Scottish soils. A Geiger–Müller X-ray spectrometer together with exchangeable cation techniques similar to those described in the preceding paper were used by Dr. B. N. Rolfe (United States Geological Survey) and Prof. C. D. Jeffries (Pennsylvania State College) to elucidate the weathering sequence of mica in soils derived from Devonian shales and sandstones under different pedogenic conditions. The results were described in a communicated paper. The weathering sequence appeared to be: unweathered mica → 'mica intermediate' → hydrated mica (vermiculite); chlorite was present during initial stages of weathering. In the discussion, the evidence for chlorite and vermiculite and the relative stabilities of these minerals to heat treatment were discussed by Mr. Brown, W. A. Mitchell and Dr. Brindley. In the final paper, Dr. Brindley described recent X-ray investigations upon antigorite. Superimposed upon a band of scattering extending upwards from 4·6 A. has been observed a sequence of sharp, closely spaced lines, indicating a super-lattice. The dimensions have been calculated, and the significance of this finding in relation to Aruja's super-lattice and Onsager's interpretation was discussed. In discussion Mr. Robertson suggested that electron-micrographs might show if the super-lattice were caused by regular corrugations.

This discussion, while showing the need for further research into methods, also amply demonstrated the wealth of information available from present techniques—and especially indicated that only by application of all techniques available can a full understanding of the mineralogy and properties of any clay be obtained.

In a report of a previous meeting of the Clay Minerals Group held in Stoke-on-Trent during November 7–8, 1952 (see *Nature*, **171**, 681; 1953), the statement on p. 682, second column, lines 18–16 from the bottom should read: ". . ., only dioctahedral components with the charge in the octahedral layer (that is, the montmorillonite type) will not swell".

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[2] MacEwan, D. M. C., *Nature*, **171**, 616 (1953).

[3] Hendricks, S. B., Nelson, R. A., and Alexander, L. T., *J. Amer. Chem. Soc.*, **62**, 1457 (1940). Macey, H. H., *Trans. Brit. Ceram. Soc.*, **41**, 73 (1942). Mackenzie, R. C., *Clay Min. Bull.*, **1**, 115 (1950).

[4] Robertson, R. H. S., Brindley, G. W., and Mackenzie, R. C., *Amer. Min.* (in the press).

[5] See *Nature*, **168**, 107 (1951).

[6] See *Nature*, **171**, 681 (1953). Schofield, R. K., and Samson, H. R., *Clay Min. Bull.*, **2**, 45 (1953).

[7] Robertson, R. H. S., and Emödi, B. S., *Nature*, **152**, 539 (1943).

[8] Galabutskaya, E., and Govorova, R., *Min. Suir'e*, **9**, 27 (1934).

SEPARATION OF CALF THYMUS DEOXYRIBONUCLEIC ACID INTO FRACTIONS OF DIFFERENT COMPOSITION

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IN the light of current conceptions, a preparation of deoxyribonucleic acid, which may be presumed to be an important component of the genetic material, could be regarded as consisting of many chemically different, though closely related, individuals, the constant composition of the whole being a statistical reflexion of the unchanging condition of the cell[1]. The composition, with respect to the distribution of

Table 1. Composition of Calf Thymus Deoxyribonucleic Acid Fractions

Experiment	Fraction	Extract of nucleohistone gel: NaCl molarity[b]	Extract of nucleohistone gel: Per cent of total nucleohistone Pe	Deoxyribonucleic acid[a]: Per cent DNA	Per cent PNA	Per cent P	Per cent protein	s(P)	η_{sp}(P)	Moles of constituent per 100 gm.-atoms Pd: Total recovery	Adenine	Guanine	Cytosine	Thymine	Molar ratio of adenine + thymine to guanine + cytosine
I	1	0·40	(42·7)	88	0·8	7·8				92·2	24·8	26·0	24·1	25·1	1·00
	2	0·84	(57·3)	105	0	8·7				99·7	30·0	20·0	18·6	30·4	1·56
II	1	0·45	(28·9)	93	0	8·5		6,600		93·0	21·2	29·0	28·3	21·5	0·75
	2	0·85	(48·5)	106	0·5	8·1				94·4	28·5	21·3	21·0	29·2	1·36
	3	1·0	(11·0)	87	0·9	6·9				96·4	27·7	22·9	20·9	28·5	1·28
	4	4·3	(11·6)	90	3·8	8·3				95·7	28·2	21·8	21·8	28·2	1·29
III	1	0	(8·0)	89	4·3	8·6		7,200	268	92·4	28·4	23·1	22·4	26·1	1·20
	2	0·50	(28·7)	93	0	8·6		6,900	335	93·8	26·6	24·5	23·6	25·3	1·08
	3	1·7	(63·3)	99	0	9·4		6,500	331	95·3	31·2	19·8	19·8	29·2	1·52
IV	1	0	3·4	101	6·1	9·2	1·5	6,700	210	94·2	28·7	22·9	22·0	26·4	1·23
	2	0·69	35·9	99	1·8	9·1	3·4	6,600	266	95·8	28·5	21·7	21·9	27·9	1·29
	3	0·73	15·4	97	1·3	9·2	2·0	6,650	318	97·1	29·8	20·6	20·6	29·0	1·43
	4	0·80	6·8	99		9·2	2·5	6,600	333	97·1	32·7	17·2	18·9	31·2	1·72
	5	0·90	5·0												
V	1	0	6·1	88	6·5	8·3	2·5	6,950		92·6	28·6	22·4	23·1	25·9	1·20
	2	0·52	24·3	94	0·2	8·9	0	6,850		96·1	26·3	24·1	24·3	25·3	1·07
	3	0·60	17·4	98	0	9·1	1·0	6,500		95·0	28·7	21·7	22·2	27·4	1·28
	4	0·76	18·4	100	0·3	9·2	0	7,000		99·0	30·2	20·1	21·0	28·7	1·43
	5	1·7	20·9	94	1·0	9·1	0·8	6,600		95·8	30·4	20·2	19·5	29·9	1·52
VI	1	0·40	3·1	54	19	7·2	10·1	7,400	129						
	2	0·45	13·7	96	0·4	8·9	3·2	6,650	301	93·3	25·8	26·4	23·8	24·0	0·99
	3	0·50	12·4	98	0	9·0	0	6,850	351	93·5	27·4	23·2	23·1	26·3	1·16
	4	0·55	16·9	99	0	9·0	1·3	6,600	386	96·2	29·5	22·0	20·9	27·6	1·33
	5	0·60	11·3	103	0	8·9	0·5	6,800	338	98·6	29·4	21·3	20·9	28·4	1·37
	6	0·75	17·3	111	0	9·2	1·0	6,600	393	98·2	31·1	19·0	20·0	29·9	1·56
	7	0·90	15·2	112	0	9·6	0	6,750	383	98·0	33·1	17·7	18·1	31·1	1·79
VII	1	0·40	10·2	95	1·1	8·8	4·7	6,400		97·6	25·4	24·8	24·3	25·5	1·04
	2	0·45	6·5	97	0	8·6	0·5	6,550		97·1	24·5	25·8	24·3	25·4	1·00
	3	1·7	42·4	100	0	9·3	0	6,600		96·0	29·7	19·8	20·9	29·6	1·46
	4	2·6	19·3	95	0·1	8·6	0·4	6,600		98·7	30·0	20·5	21·0	28·5	1·41

a The contents in deoxyribo- and pentose nucleic acids were determined colorimetrically with highly purified specimens as the reference standards[1]. Phosphorus was estimated by a colorimetric procedure[15], protein by an adaptation of the biuret reaction with crystalline egg albumin as the standard. *s*(P), the atomic extinction coefficient with respect to phosphorus[16], was measured in 0·1 *M* phosphate buffer of *p*H 7·1. η_{sp}(P) is the specific viscosity (Ostwald–Fenske viscosimeter, outflow time for 0·1 *M* NaCl 62·7 seconds at 29·5°) divided by the molarity of the solution with respect to P; solutions in 0·1 *M* NaCl, containing about 15 γ of P per c.c., were employed.

b The salt concentrations in Experiments I to III were estimates; in Experiments IV and V chloride was determined titrimetrically[17]; in Experiments VI and VII the NaCl concentration was adjusted, as described in the text.

c The figures in parentheses (Experiments I to III) are based on the phosphorus distribution in the listed nucleic acid fractions. All other figures represent the quantity of P found in the particular extract as per cent of the total nucleohistone P subjected to fractionation.

d The actual total average recovery of moles of nitrogenous constituents per 100 gm.-atoms of P is indicated in the first column. The mean proportions of each constituent have been corrected for a 100 per cent recovery, in order to facilitate comparison.

purines and pyrimidines, of deoxyribonucleic acid preparations isolated from the same species is indeed remarkably constant, though far-reaching species differences have been observed frequently[2–5]. As extreme examples of what we have termed the *GC* and *AT* types, respectively[4], the molar proportions of adenine to guanine may be quoted which amount to 0·4 in the deoxyribonucleic acid of the avian tubercle bacillus[6], but to 1·9 in the corresponding preparation from the sperm of *Paracentrotus lividus*[7]. An intermediate type, containing all nitrogenous constituents in nearly equimolar quantities, has been encountered only in *E. coli*[8,9].

The composition of the deoxyribonucleic acid of calf thymus is of particular relevance to the topic to be considered here. Twenty-one specimens of this nucleic acid, prepared by several procedures, showed no more than minute deviations in composition. The following mean proportions in moles of nitrogenous constituent per 100 gm.-atoms of phosphorus (with the standard error in parentheses) were found[10]: adenine 29·0 (0·2); guanine 21·2 (0·2); cytosine (including the small amount of 5-methylcytosine occurring in this nucleic acid[11]) 21·2 (0·2); thymine 28·5 (0·2); molar ratio of adenine + thymine to guanine + cytosine 1·36. Regularities applying to all deoxyribonucleic acids studied in this laboratory have been pointed out before: the sum of purine nucleotides equals that of pyrimidine nucleotides; the ratio of adenine to thymine is nearly 1, and so is that of guanine to cytosine (+ 5-methylcytosine); the proportion of amino groups to enolic hydroxyls is around 1·5 [2–4].

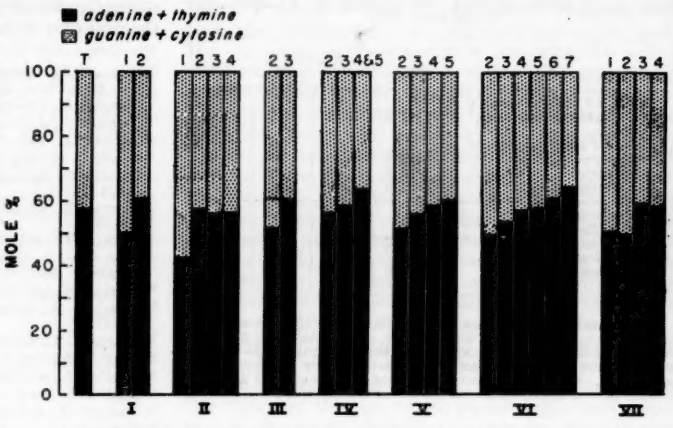
Although the possibility that a deoxyribonucleic acid preparation from a given species represents a mixture of many different individuals has been discussed before[1,2,5], records of attempted fractionation are not numerous. Preparations isolated from the cell by non-destructive procedures apparently are not separable into specimens of different composition by fractional centrifugation[11] or adsorption on charcoal[12]. Nucleic acid preparations extracted from tissues at a very high temperature (85°) have been separated into two fractions differing in their solubility in physiological saline and in the extent to which previously administered carbon-14 had been incorporated into the various purines and pyrimidines[13,14].

In the course of studies on calf thymus nucleohistone, which will be presented on a later occasion, it was observed that deoxyribonucleic acid fractions of divergent purine and pyrimidine contents could be isolated by what may be described as fractional dissociation of the nucleoprotein.

The essential steps in the fractionation experiments, which were carried out at about 4°, the results of

which are summarized in Table 1, were as follows. (1) Fresh, minced calf thymus tissue, washed with physiological saline and then with small portions of distilled water, was extracted with a five-fold weight of distilled water. (2) The aqueous nucleohistone solution, comprising about 90 per cent of the total nucleic acid of thymus, was treated in a high-speed mixer for five minutes with one-half volume of a mixture of chloroform and *n*-octanol (9 : 1 by volume)[18]. Centrifugation at 20,000 *g* for fifteen minutes produced a loosely packed gel and an opalescent supernatant solution which was twice more treated with chloroform–octanol. (3) The combined gels were extracted stepwise with sodium chloride solutions of increasing concentration, each treatment in the high-speed mixer being followed, after an interval of at least thirty minutes, by centrifugation at 2,000 *g*. (4) The precipitate resulting from the addition of two volumes of ethanol to each extract was dissolved in 10 per cent sodium chloride, deproteinized by repeated treatment with chloroform–octanol, and the aqueous solution of the nucleic acid was, after re-precipitation with alcohol, freed of electrolytes by dialysis and of water by evaporation *in vacuo* in the frozen state. In Experiments VI and VII (Table 1) steps 2 and 3 were modified: after the treatment of the aqueous nucleohistone solution with chloroform, a known salt concentration was established by the addition of solid sodium chloride; the mixture was stirred for five minutes, kept for 30 minutes and then centrifuged for the same period at 2,000 *g*. The amount of salt and of water remaining in the sediment could be estimated from the volume of the supernatant solution. In all subsequent extractions the desired sodium chloride molarity and a volume of water equal to that of the original nucleohistone solution were maintained by the addition of sufficient quantities of water and salt.

The principal analytical results are assembled in Table 1. Distilled water extracted only small amounts of deoxyribonucleic acid (for example, fractions III-1, IV-1, V-1); and these specimens, as also occasionally the first salt extracts (for example, fraction VI-1), were contaminated with pentose nucleic acid. Not all such minor fractions have, therefore, been tabulated, though they, as well as the residues of the final extraction, were included in the establishment of phosphorus balances. In Experiment V 92·4 per cent of the total nucleohistone phosphorus could thus be accounted for, in Experiment VI 89·3 per cent, and 84·2 per cent in Experiment VII. Fraction II-1, as isolated initially, contained 3·7 per cent of pentose nucleic acid and was contaminated with non-phosphorylated material; it was purified by treatment with charcoal[12]. The values for individual purines and pyrimidines are averages of at least two independent hydrolysis experiments in each of which 12 to 24 determinations of each constituent were performed. The hydrolysis and estimation procedures have been described previously[19]. In many instances hydrolysis with perchloric acid[20] also was employed.



Composition of calf thymus deoxyribonucleic acid fractions (in moles per 100 gm.-atoms of phosphorus). The experiments and fractions are numbered as in Table 1. The first column (*T*) indicates the average composition of the total deoxyribonucleic acid[16]

The results of the fractionation are most clearly seen in the figure in which the molar sums of adenine and thymine found in each significant fraction are contrasted with the corresponding sums of guanine and cytosine. It will be noticed that the gradual extraction of the nucleoprotein with salt solutions of increasing strength yields a series of nucleic acid fractions with diminishing concentrations of guanine and cytosine and rising concentrations of adenine and thymine. The equimolarity of each pair of constituents and of total purines and pyrimidines is, however, maintained[2] (see Table 1). Fractions II-1 and VI-7 show the greatest divergence from the composition of total calf thymus deoxyribonucleic acid; but the trend is unmistakable in all cases. When the increments contributed by each fraction are computed, an average composition results which is almost identical with that of total calf thymus deoxyribonucleic acid quoted at the beginning.

The study of the composition of the various fractions was not limited to the four major nitrogenous constituents listed in Table 1. It appeared of particular interest to investigate the distribution of 5-methylcytosine which is known to occur, mostly as a minor component, in many deoxyribonucleic acids[11] and has been isolated from that of calf thymus in the form of its nucleotide[21]. For the quantitative determination of this pyrimidine, hydrolysates of the fractions collected in Experiment VII (20–25 mgm. of nucleic acid in 0·5 ml. of concentrated formic acid) were subjected, in 0·04–0·06 ml. aliquots, to paper chromatography with distilled water which, in the arrangement described previously, permitted the separation of purines from pyrimidines. The purine zones then were cut off and the irrigation was continued with a mixture of six volumes of *n*-butanol and one volume of 0·1 *N* ammonia[19]. The results summarized in Table 2 show significant divergences in the concentration of this satellite in the several fractions and may be considered as additional proof that the fractionation of the deoxyribonucleic acid of calf thymus has been achieved. The average contents of 5-methylcytosine computed from the figures reported here are in good agreement with its concentration in total thymus nucleic acid[11,23].

The fractionation presented here rests probably on differences in the stability of the bonds between

Table 2. 5-Methylcytosine Distribution in Fractionation Experiment VII*

	Fraction 1	2	3	4
Moles per 100 gm.-atoms of P				
Pyrimidines recovered	41·2	52·2	45·7	46·3
Corrected mean proportions				
Thymine	24·2	24·0	29·0	28·7
Cytosine	23·9	23·4	19·8	21·3
5-Methylcytosine	1·9	2·7	1·2	0
Molar ratio				
Thymine to 5-methyl-cytosine	12·7	8·9	24·2	
Cytosine to 5-methyl-cytosine	12·6	8·7	16·5	

* The moles of pyrimidines actually found per 100 gm.-atoms of phosphorus are reported in the first line. The mean proportions of each constituent have been corrected on the assumption that one-half of the nucleic acid phosphorus is contributed by the pyrimidine nucleotides. In one hydrolysis experiment with Fraction 4 a minute amount of 5-methylcytosine (about 0·6 mole) was found.

nucleic acid and protein. The extent, however, to which both partners, the nucleic acids and the proteins, are concerned in this behaviour, cannot yet be evaluated; nor can it be decided whether the various conjugated proteins, of which nucleohistone presumably is composed, share the same protein or whether numerous combinations of different nucleic acids and different proteins occur. As regards the nucleic acids themselves, which, as has been shown here, can be separated into fractions of different composition, the following list of possibilities is by no means exhaustive. (1) The fractions are degradation products; an unlikely assumption not borne out by the spectroscopic and viscosity measurements provided in Table 1. Moreover, the isolation procedures did not exceed in vigour those usually employed for the isolation of nucleic acid. (2) Deoxyribonucleic acid is a mixture either of polyadenylic, poly-guanylic acids, etc., or of purine polynucleotides and pyrimidine polynucleotides, or of copolymers consisting exclusively of adenylic and thymidylic acids on one hand, and of guanylic and cytidylic acids on the other. These assumptions are contradicted by most of the available chemical evidence. (3) A slightly more plausible formulation may be seen in the view that deoxyribonucleic acids are composed of varying quantities of two extreme varieties, one predominantly containing equimolar amounts of adenine and thymine, the other of guanine and cytosine. (4) The most likely supposition—and one receiving some support from the distribution of fractions, for example, in Experiment VI—is that one is dealing with a very large number of differently constituted individuals, with an entire spectrum of structural gradations, in which the regularities mentioned before are maintained.

The extension of the present observations to other fractionation studies will be described later. They may contribute better material for X-ray work; and it should be of particular interest to apply them to deoxyribonucleic acids that are active in inducing bacterial transformation.

One of us (C. F. C.) took part in this work as a Fellow of the National Foundation for Infantile Paralysis. The research was aided by grants from the American Cancer Society on the recommendation of the Committee on Growth of the National Research Council and from the Rockefeller Foundation.

[May 20.

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PORPHOBILINOGEN AS A PORPHYRIN PRECURSOR, AND INTERCONVERSION OF PORPHYRINS, IN A TISSUE SYSTEM

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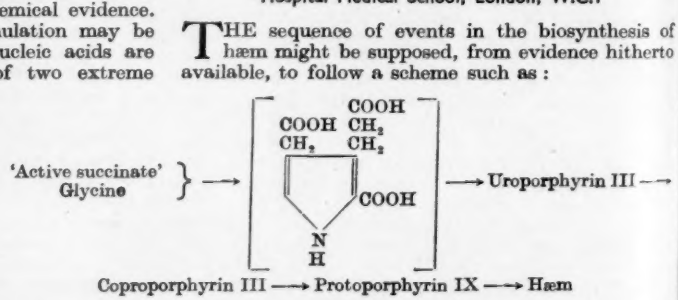
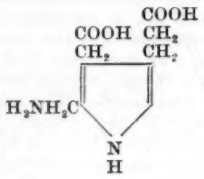
THE sequence of events in the biosynthesis of hæm might be supposed, from evidence hitherto available, to follow a scheme such as:



(I)

The evidence can only be summarized briefly here: utilization of glycine and 'active succinate' in the formation of hæm has been established by the work of Wittenberg and Shemin[1], Muir and Neuberger[2], and Shemin and Kumin[3]. The requirement of glycine for the biosynthesis of free protoporphyrin has been shown by Bénard, Gajdos and Gajdos-Tőrők[4]; in addition, Dresel and Falk[5] have established that eight α-C atoms of glycine are incorporated into each molecule of protoporphyrin synthesized, just as has been found for hæm synthesis[1,2]. The

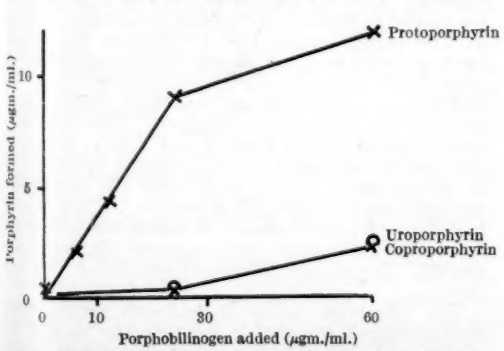
conversion of radioactive uroporphyrin III to protoporphyrin has been demonstrated by Salomon, Richmond and Altman[6], using rabbit bone-marrow homogenates. The place of coproporphyrin in the sequence, though chemically feasible, is supported only by indirect evidence (cf. Watson[7]). That protoporphyrin is converted to its ferrous complex, hæm, by tissues might appear self-evident; but this conversion has not yet been demonstrated experimentally. It is quite conceivable, though iron–porphyrin complexes other than hæm are not found, that a transient iron complex of a porphyrin other than protoporphyrin may be the true hæm precursor.



(II)

An intermediate such as the pyrrole tricarboxylic acid resulting from condensation of two molecules of 'active succinate' with glycine (I) was indicated by the results of Shemin and Kumin[3]. The probable structure for porphobilinogen (II) recently advanced by Cookson, Rimington and Kennard[8], following its isolation by Westall[9], is very similar to this pyrrole tricarboxylic acid. This similarity, together with the facts that porphobilinogen is excreted in disturbances of porphyrin metabolism[10] and is converted easily and non-enzymically to uroporphyrin[8,9], all suggested that it might be a normal porphyrin precursor. The preparation of hæmolysed chicken erythrocytes, being used in this laboratory[11,12] for studies of the mechanisms of blood pigment biosynthesis, offered a very favourable system for the direct investigation of this possible role of porphobilinogen, and also of some of the porphyrin interconversions shown in (I).

On incubation with the hæmolysate in air, porphobilinogen was converted to proto-, copro- and uroporphyrins as shown in the accompanying illustration. At a concentration of about 10 μgm./ml., about 60 per cent of the porphobilinogen was converted to protoporphyrin; no significant amount of porphobilinogen remained unchanged, although 94 per cent of that added was recovered after incubation in the same way with a boiled hæmolysate. Some of the porphobilinogen has thus not been accounted for;



Conversion of porphobilinogen to porphyrins. Hæmolysate (ref. 12) incubated 4 hr. at 38° C. with shaking in air

but it is probable that a considerable proportion of this was converted, *via* protoporphyrin, to hæm. We are planning to investigate this with the aid of radioactive porphobilinogen. Porphobilinogen may also have been lost through its conversion to porphobilin and other non-porphyrin pigments, or to colourless porphyrin precursors (cf. Brockman and Gray[13]); these possibilities are being investigated. As might be expected, the conversion of porphobilinogen to protoporphyrin is not inhibited by 2:4-dinitrophenol, which effectively inhibits the synthesis of protoporphyrin from glycine[5]. It was of some interest to determine whether the enzymes concerned in the conversion of porphobilinogen to porphyrins are present in solution, or whether they are associated with the solid material (ghosts, etc.) obtained when the hæmolysate is centrifuged at high speed (15,000 *g* at 2°). The solids were washed twice with, and resuspended in, 0·9 per cent potassium chloride, and the fate of porphobilinogen on incubation with the solids and supernatant was studied. Whereas the recombined fractions brought about a 60 per cent conversion of porphobilinogen to protoporphyrin, identical to that obtained with the unfractionated hæmolysate, porphobilinogen incubated with the solids alone was all recovered unchanged; incubation with the supernatant alone resulted in conversion of about 24 per cent of the added porphobilinogen to porphyrin, which was, however, mainly coproporphyrin.

PORPHYRINS FORMED FROM PORPHOBILINOGEN UNDER AEROBIC AND ANAEROBIC CONDITIONS BY RED CELL HÆMOLYSATES

Incubation	Porphobilinogen recovered	Uroporphyrin	Coproporphyrin	Protoporphyrin
4 hr. air	2	0	1	61
4 hr. N_2	3	11	14	5
2 hr. N_2	20	15	8	2
2 hr. N_2, then 2 hr. air	2	1	11	47

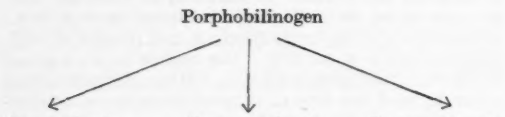
Hæmolysate shaken at 38° with porphobilinogen (25 μgm./ml.). All figures are percentages of the porphobilinogen added

For its conversion to protoporphyrin, both decarboxylation and dehydrogenation of two of the propionic acid side-chains of coproporphyrin are necessary. It was possible that the dehydrogenation might require aerobic conditions; indeed, this was indicated by the finding of Bénard, Gajdos and Gajdos-Török[14], that blood from phenylhydrazine-poisoned anæmic rabbits formed mainly protoporphyrin when incubated with glycine aerobically, but predominantly coproporphyrin when incubated similarly under nitrogen. We have found that incubation of the hæmolysate with porphobilinogen under nitrogen results in an accumulation of uroporphyrin and coproporphyrin, the formation of protoporphyrin being greatly reduced. In an attempt to show directly the conversion of coproporphyrin to protoporphyrin, a flask was incubated under nitrogen for 2 hr., then aerated, and incubated in air for a further 2 hr. Protoporphyrin, in fact, increased greatly after the aeration; but, although uroporphyrin disappeared, the coproporphyrin content was little changed (see table).

The constitutions of the free porphyrins formed in these experiments were checked by paper chromatography in a lutidine–water system[15]; the porphyrins were also esterified, and the esters subjected to isomer-analysis by paper chromatography[16,17]. Both the uroporphyrin and the coproporphyrin formed

from porphobilinogen behaved mainly as the III-series isomers.

As we had found conversion of porphobilinogen to uro-, copro- and protoporphyrins, it was interesting to attempt a direct demonstration of interconversion of these porphyrins. On incubation of pure uroporphyrin III (3 μgm./ml.) with the hæmolysate, 52 per cent was converted to protoporphyrin. This provides a direct confirmation of Salomon, Richmond and Altman's demonstration[6] of the same conversion by an isotope-tracer method. Incubation with pure coproporphyrin III (3 and 9 μgm./ml.) resulted in no significant formation of protoporphyrin, and most of the coproporphyrin was recovered unchanged.



Uroporphyrin ——————→ Protoporphyrin

(III)

The conversions we have so far shown are summarized in (III). These are end-results, and we do not yet know, for example, whether uroporphyrin on one hand and porphobilinogen on the other are converted to protoporphyrin *via* the other porphyrins or not. Further, though there is no doubt that the tissue can bring about these conversions, this alone does not prove that porphobilinogen or uroporphyrin are normal intermediates in the biosynthesis of hæm. An investigation into whether these substances are formed under conditions favourable for hæm synthesis might throw light on this problem. We have been able to isolate radioactive porphobilinogen, uroporphyrin and coproporphyrin from hæmolysates incubated with radioactive glycine in the presence of 'carrier' porphobilinogen, uroporphyrin and coproporphyrin, respectively. The possibility of contamination with radioactive glycine, or with radioactive protoporphyrin, was excluded. Thus we have shown that, besides protoporphyrin[11,12], porphobilinogen, uroporphyrin and coproporphyrin are all synthesized from glycine in the hæmolysate. These results will be discussed in greater detail elsewhere.

We thank Miss A. Benson and Mr. F. Grover for their skilled assistance, Mr. R. G. Westall for a gift of porphobilinogen and the Nuffield Foundation for making this work possible.

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X-RAY SCATTERING EVIDENCE REGARDING THE PROTEIN–NUCLEIC ACID COMBINATION IN NUCLEOPROTEINS

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VARIOUS hypotheses have been advanced concerning the way in which the nucleoprotein complex is built up from its two components, nucleic acid and protein (histone or protamine). On one hand, it has been suggested that the combination of the two constituents is intimate and that the protein polypeptide chains are closely aligned with, or coiled around, the nucleic acid chains. The implication in these hypotheses is that the protein polypeptide chains are, at least partially, unfolded from the configuration existing in the separated protein molecules; several authors have suggested that this unfolding is complete and that the polypeptide chains have the fully-extended β-configuration. The most contrasted hypothesis is that the nucleoprotein molecule is simply an addition complex of protein plus nucleic acid held together, principally, by salt linkages. The protein moiety is considered to be essentially identical in structure with the separated fraction.

It occurred to us that a quantitative comparison of the X-ray scattering curves given by amorphous samples of nucleic acid, protein and nucleoprotein, respectively, might allow a decision to be reached about the nature of the combination, irrespective of any assumptions concerning the exact structures of the components. The intensity of scattering from an addition complex of two bulky macromolecules should, fairly exactly, be the sum of the intensities scattered separately by the two individual constituents. This would not be the case with small molecules, because of the relatively greater importance of interference terms; nor, for the same reason, would it hold for an intimate type of close combination of filamentous macromolecules, such as would be provided by intertwining. In such an instance, the scattering would show qualitatively new features not given by either component separately.

Through the kind co-operation of Prof. J. A. V. Butler and Mr. P. F. Davison, we have been able to investigate nucleoprotein specimens which they have separated from herring sperm and calf thymus with the minimum amount of chemical treatment[1], so that it is reasonably certain that the samples are native nucleoproteins and not reconstituted aggregates of components liberated during the extractions. In addition, the corresponding separated proteins and nucleic acids have been examined. The intensity curves reproduced in Figs. 1 and 2 were obtained from air-dry compacts of six specimens by means of a counter-spectrometer and refer to practically monochromatic copper $K\alpha$ radiation. All the curves have been put on the same normalized absolute scale by equating them at high values of $(\sin\theta)/\lambda$ (not drawn). The accuracy attained was about ± 2 per cent.

The additional curves drawn with broken lines were obtained by adding together the values for protein and nucleic acid in the proportions of 58 per cent histone + 42 per cent nucleic acid for the

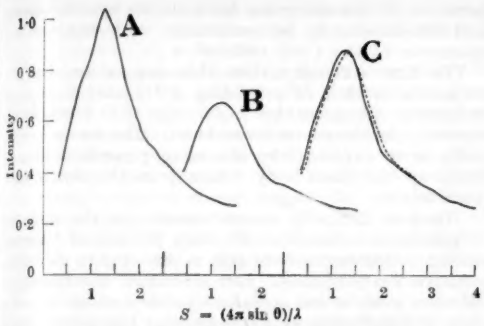

Fig. 1. Normalized X-ray scattering curves from herring sperm preparations: *A*, clupein sulphate; *B*, nucleic acid (Na salt); *C*, nucleoprotein. Dashed curve represents sum of 56 per cent *A* and 44 per cent *B*. Origins for *B* and *C* displaced to the right as indicated by the longer lines on the horizontal scale

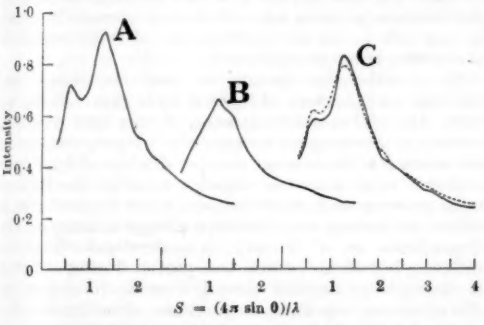

Fig. 2. Normalized X-ray scattering curves from thymus preparations: *A*, histone sulphate; *B*, nucleic acid (Na salt); *C*, nucleoprotein. Dashed curve represents sum of 58 per cent *A* and 42 per cent *B*. Origins displaced as in Fig. 1

thymus preparations and 56 per cent clupein + 44 per cent nucleic acid for the herring sperm samples. (These compositions are sufficiently exact and are derived from the nitrogen–phosphorus ratios obtained by analysis of the nucleoproteins.) They therefore represent the scattering to be expected if the nucleoproteins are simple addition products. As will be seen from the figures, the agreement with the intensity curves measured directly on the nucleoprotein specimens themselves is good.

In the case of the herring sperm preparations (Fig. 1), only one peak is observed, and the curves are rather featureless. Nevertheless, we would not expect the agreement between the summation curve and the observed nucleoprotein scattering to be as close as it is if the nucleoprotein were other than a fairly gross addition complex. In particular, we think that Watson and Crick's attractive suggestion[2] that the polypeptide chain is of the fully-extended β-type and wound in a specific and intimate way around the axis of the nucleic acid double-helix is unlikely to be true as regards this material in the form examined by us.

This is even more evident when the equivalent intensity curves (Fig. 2) for the thymus preparations are considered, as it is particularly difficult to account for the persistence of the inner 10-A. protein peak except by preserving the protein structure essentially intact in the nucleoprotein complex. Again, were the Watson–Crick hypothesis correct, one would expect scattering curves of similar type to be given by the two nucleoproteins: certainly, there would be no reason for a 10-A. peak to occur in the thymus material but not in that from herring sperm. The 10-A. peak is almost certainly due to the parallel grouping of several neighbouring polypeptide chains to form a bundle. Work not yet published in detail[3] suggests that histone possesses the α-helix structure of Pauling and Corey, although this assumption is not necessary to the present argument.

The agreement between the calculated and measured curves for the two nucleoproteins, while good, is not perfect. Part of the reason for this may be that the separated proteins were examined in the form of sulphates and the nucleic acids as the sodium salts, whereas in the native nucleoproteins these inorganic ions are absent. The discrepancy in the case of thymus preparations is, however, sufficient to require explanation, as no reasonable alteration in the proportions of the two constituent curves will lower the 10-A. peak and, at the same time, raise the 5-A. peak, to be coincident with the observed positions. It would appear either that the separated histone sample does not represent the totality of the protein moiety of the nucleoprotein or that its structure has been modified, although not greatly, in the course of extraction. It appears certain[4] that thymus histone is not a homogeneous protein, and various fractions with which we have been provided do, indeed, show differences in their scattering curves. The possibility of some degradation during extraction[5] must also always be present. Nevertheless, our results would not exclude the possibility that partial unfolding of the histone molecule occurs when it forms its addition complex with nucleic acid. By 'partial unfolding', we mean only that the parallel grouping of polypeptide chains is somewhat affected, but not the manner in which the chains themselves are coiled into a regular configuration, such as that of the α-helix.

It is of interest to note that the curves for the two sorts of nucleic acid are not absolutely identical, although they are closely similar. This observation must reflect differences in structure. Another fact worthy of remark is that, in the case of the air-dry 'amorphous' nucleic acids, no peak whatever appears corresponding to a parallel grouping of molecules. Such a peak, as was shown in earlier work[6], is a prominent feature of the scattering from aqueous gels of nucleic acid (sodium salt) over a very wide range of concentration, and the crystalline phase also exhibits diffraction lines which are the equivalent. The organizing role of water is obviously of great importance with this molecule and probably also with its natural complexes with protein. Therefore, it is not inconceivable that the conclusions reached in this paper would not apply to nucleoproteins in the living cell.

The investigation reported here forms part of researches supported by grants from the British Empire Cancer Campaign.

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LETTERS TO THE EDITORS

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Cosmic Origin of Radiation at Radio Frequencies

The recent identification by W. Baade and R. Minkowski of the intense discrete radio source in Cygnus as being an emission from two colliding galaxies[1] raises a number of interesting theoretical questions. In the first place, the only material likely to be seriously disturbed by such a collision is the diffuse interstellar material lying between the stars in these galaxies. Consequently, it would seem profitable to seek a process of generation of radio waves that takes place in extremely diffuse gas clouds. Secondly, processes of magnetic resonance requiring field intensities of many gauss, such as the Larmor precession, would seem to be excluded, since fields of this intensity could scarcely be maintained throughout regions of galactic dimensions.

It is natural to assume that the high velocity of collision of the two galaxies, perhaps of the order of 2,000 km. per sec., plays an important part in the generation of the radio waves that we receive from the Cygnus source. This view is supported by Minkowski's recent work[1] on the well-known source in Cassiopeia. The Cassiopeia source originates in a group of gaseous filaments within our own galaxy. Minkowski finds that these filaments show internal relative velocities up to 3,000 km. per sec., which, apart from the velocities of expansion of nova and supernova shells, is unprecedentedly large for motions within the galaxy. Mention of supernovæ recalls that the Crab nebula is also a discrete radio source, and that the material of this nebula also possesses high velocity, of the order of 1,000 km. per sec.

Now a high velocity probably implies a high electron temperature. Hence it is not certain that the radio emission owes its origin directly to motions of large masses: it may arise thermally as a result of high temperature. Of these two possibilities the thermal case is much the simpler to consider, and it is this case which forms the subject of the present communication.

The suggestion that the radio emission from such sources as those of Cygnus, Cassiopeia, and of the Crab nebula is of thermal origin may seem somewhat surprising in view of the objections that have frequently been raised against it[2]. Yet the suggestion derives an immediate plausibility from the circumstance that black-body emission in the metre wave-band would adequately explain the observed intensities of these sources. Thus two spiral galaxies colliding head-on at a relative speed of 2,000 km. per sec. must come to be surrounded by an ionized gas cloud with an electron temperature of order 10^6 deg. K. and with dimensions of order 10,000 parsecs. Black-body emission at the appropriate frequencies from such a cloud yields an intensity sufficient for the Cygnus source; indeed the intensity would be sufficient for the system to be detectable as a discrete radio source even if it were to lie at a distance of nearly 1,000 million parsecs, which is beyond the optical range of the greatest telescopes[2]. Or again, black-body emission at about 10^6 deg. K. would be sufficient to explain the observed intensity of the Crab—it being noted that an electron temperature of this order has been shown by Greenstein and Minkowski to be consistent with the optical spectrum of the Crab nebula[2].

The first difficulty that this suggestion has to overcome is that of providing a thermal source of radiation adequate to build up the black-body intensity in the metre wave-band. The second difficulty is to explain why the same process does not build up the black-body intensity in the centimetre wave-band.

The first difficulty arises because, in the absence of magnetic resonances, the only process of thermal emission that seems available is that due to electron-positive ion collisions. But the usual treatment of electron-positive ion collisions yields a radiation-rate that is insufficient to maintain the black-body rate by a large margin—by a factor of roughly 10^2 in the case of the Crab, and by about 10^4 for two colliding galaxies. Accordingly, escape from the present difficulty would seem to depend on our being able to maintain successfully that the usual treatment of the electron-positive ion collision problem is in error, at any rate so far as the emission of radio waves in the metre band is concerned.

To consider this matter, we treat the case where the material consists of ionized hydrogen. First, we note that the usual treatment of this case yields a radiation-rate per unit volume which is proportional to n^2, where n is the average number density of hydrogen atoms: n is also the average number density of both protons and electrons, since the ionized gas is taken as having zero average charge density. The dependence on n^2 is easy to understand when the distance between electron and proton during collision is appreciably smaller than the mean inter-particle distance—we say that the number of collisions of a particular electron is proportional to the proton density n, and since there is an average of n electrons per unit volume, this immediately gives a radiation-rate per unit volume proportional to n^2. But how if the typical collision distance for the emission of radio waves is much greater than the mean inter-particle distance? How do we interpret the dependence on n^2 in this case?

To approach this question, we note that radiation arises from the acceleration of electrons in the Coulomb fields of the protons. A wave of frequency f arises mainly from accelerations that vary appreciably in a time $1/f$. In this time an electron moving with velocity v travels a distance v/f. Hence the emission of frequency f arises from accelerations that vary during the passage of electrons through distances of order v/f; that is to say, v/f gives the order of the collision distance for the emission of frequency f.

Now when v^2n/f^2 is large compared to unity, we must take account of fluctuations in the distribution of the protons and electrons. At any given time the number of protons within distance v/f from a particular electron will not usually equal exactly the number of electrons within this distance, although on taking a time average the two numbers become essentially equal in an uncharged gas. Stated otherwise, there will in general be a difference between the numbers of electrons and protons that are within distance v/f from a particular electron; and if the positions of the particles are at random, then by well-known considerations this difference must be of order $(v/f)^{3/2} \cdot n^{1/2}$. Hence the electron is accelerated not by just one elementary charge but by $(v/f)^{3/2}\, n^{1/2}$ units of charge. Since the rate of radiation is proportional to the square of this acceleration, we

obtain a rate per electron proportional to n; and consequently a radiation-rate per unit volume proportional to n^2, as before.

The clue to our problem lies in the foregoing. If the positions of the protons and electrons are not distributed at random, if a separation of charge has occurred for some reason, then the charge excess within distance v/f from a particular electron may considerably exceed $(v/f)^{3/2}\, n^{1/2}$. Indeed, in the case of a nearly complete charge separation, the electrons accelerate under the influence of $(v/f)^3\ n$ units of charge—instead of under the influence of $(v/f)^{3/2}\, n^{1/2}$ units of charge as in the usual treatment. This increases the radiation-rate by $(v/f)^3\ n$, which for $f = 10^8$ cycles per sec. gives a factor of about 10^8 in the case of two colliding galaxies (choosing v to correspond to an electron temperature of 10^8 deg. K.). This factor is of the order required to overcome the discrepancy mentioned above. Not only this, but the strong dependence on f shows that the present process of emission weakens rapidly as the frequency rises. This would seem to offer hope of overcoming the second of the difficulties mentioned above.

A slight modification of the above argument is required for the case of the Crab, since the material in this case is not essentially pure hydrogen (hydrogen being in low concentration). The modification does not alter the main feature of the argument, however: that an appreciable charge separation increases the rate of radiation by a large factor. It may be added that absorption processes increase correspondingly, the increase being such as to limit the radiation field to the Planck intensity.

It remains to remark on the cause of a separation of charge. It is well known that charge separation must occur when an ionized gas is in motion in the presence of a magnetic field; and a magnetic field, perhaps of order 10^{-6} gauss, is likely to be present in our case. There is therefore no difficulty in understanding, in principle, how charge separation can arise. Further considerations are, however, required in order to discover the conditions under which the charge separation may become nearly complete, as is necessary if the greatest rate of radiation is to be obtained. It must suffice in the present communication to remark that nearly complete separation may occur at the surface of isolated elements of material, or if the elements of material are very small. These requirements are of interest in relation to observations of the Cassiopeia source, which show it to consist of many broken and apparently separated filaments[1].

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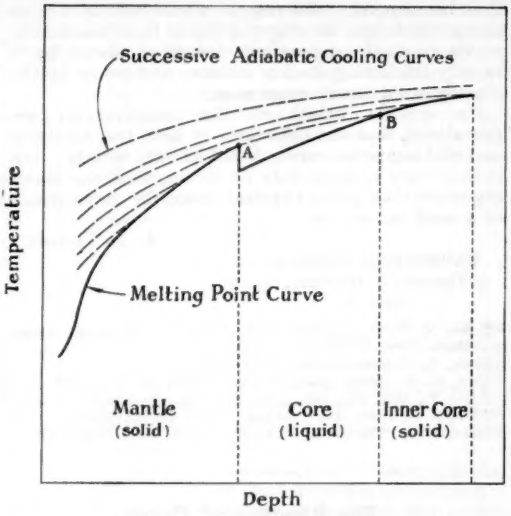
The Earth's Inner Core

All seismic work indicates that at least part of the core of the earth is liquid, since no transverse waves have ever been observed to pass through it. It has been suggested, however, that the core contains an inner core beginning at a depth of approximately 5,000 km. which is solid, although no definite proof of this has ever been given. Bullen[1], however, has shown that the rise in velocity of longitudinal waves at this depth can be explained by assuming it to be solid and of the same composition as the rest of the core. In a recent and detailed analysis of the constitution of the earth's interior, Birch[2] comes to the conclusion that the inner core is most probably crystalline iron, and the outer part liquid iron, perhaps alloyed with a small fraction of lighter elements.



Most theories of the origin of the earth agree that it passed through a molten stage before finally separating into the different layers; but no physical explanation seems to have been given as to how the inner core could have become solid. Urry[3] has shown that even an earth formed from the cold accretion of dust particles would melt by the accumulation of heat from radioactive elements, and afterwards solidify as the amount of radioactive material decreased with increasing age of the earth. Hoyle[4] has also shown that accretion should lead to a liquid planet.

Assuming the core to consist mainly of iron and the mantle of silicates, the melting-point curve is likely to be of the general shape shown in the figure. The recent work of Uffen[5] (based on seismic data and the theory of solids) has shown that the melting-point gradient in the mantle is considerably less than the theoretical curve proposed by Jeffreys[6]. At the boundary of the core and mantle there will be a discontinuity, the melting point in the iron core being less than that in the silicate mantle.

As the earth cooled from its molten state, the temperature gradient would be essentially adiabatic, there being strong convection currents and rapid cooling at the surface. Solidification would commence at that depth at which the curve representing the adiabatic temperature first intersected the curve representing the melting point temperature. It is suggested, therefore, that solidification began at the centre of the earth, and not at the boundary of the core and mantle as it is at present supposed. A solid inner core would continue to grow until a curve representing the adiabatic temperature intersected the melting-point curve twice, once at A, the boundary of the core and mantle, and again at B, as shown in the figure. As the earth cooled still further, the mantle would begin to solidify from the bottom upwards. The liquid layer between A and B would

thus be trapped. The mantle would cool at a relatively rapid rate, leaving this liquid layer essentially at its original temperature, insulated above by a rapidly thickening shell of silicates and below by the already solid (iron) inner core.

No specific values of the temperatures are postulated, and the behaviour of both the adiabatic and melting-point curves is not known exactly; but if they vary qualitatively as shown, then the above argument does give a physical reason for the existence of a solid inner core.

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The Rheological Curve

The shear of a non-Newtonian body, that is, a plastic material or a high-polymeric pseudo-fluid, follows a mechanism showing analogy to that of a true fluid as expressed by the Maxwell equation; but whereas the relaxation of true fluids is purely time-dependent, in the case of non-Newtonian bodies a critical angle of tangential deformation characteristic for each material marks a threshold limit of elastic deformation before relaxation sets in. This elastic limit in plastic materials corresponds to the separation of a secondary aggregate into primary particles and, in the case of pseudo-fluids, to the inception of unkinking of the polymer molecules.

From a study of rheological data derived from non-Newtonian plastic bodies and high-polymer sols of cellulose esters, etc., we find the geometrical characteristics of the stress/shear-rate relationship to conform to a line, the curvature of which decreases with increasing velocity gradient:

$$d^2S/dv^2 = -(K)\exp(-T.v),$$

where S is the applied shearing stress, v the velocity gradient, and K and T are constants characteristic of the material.

If the very short relaxation time of the Maxwellian fluid component be considered as negligible by reason of the great magnitude of the time-scale of experimental observation, $1/T$ will be the measure of a constant rate opposing v, and a Newtonian linear relationship will be reached when the exponential term vanishes at high rates of shear. Thus, at $v = 0$, the exponential term assumes its maximum value of K/T^2.

The rheological measurements in a capillary instrument are derived solely from the stress–shear mechanism immediately contiguous to the wall-layer, and the experimental line can be expressed by the equation:

$$S = v/\mu + F_0 - (K/T^2)\exp(-T.v),$$

where $1/\mu$ is the residual or plastic viscosity measured along the asymptote, and K/T^2 is the value of the difference between the intercept to the asymptote F_0 and that of the curve on the stress axis F_1, were the regime maintained down to the value $v = 0$.

Materials of low rigidity exhibit curves which appear to have their origins at lower values of stress than is the case with materials of high rigidity. In conformity with this, the values of $(F_0 - K/T^2)$ are smaller in proportion to the Bingham intercept F_0 in the former than with the latter type.

It is probable that when the experimental line appears to cut the stress axis at a point lower than the calculated value F_1 of the curve, this is due to a progressive change in the regime to a two-dimensional planar flow ruling at very low velocity gradients, as in, for example, parallel-plate plastometry.

The value F_1 of the intercept to the curve at its origin may be determined by plotting $\ln(\Delta S)$ against the corresponding values of v, when the intercept on the ln axis gives K/T^2 and the slope of the curve gives T.

The degree of flocculation of a given material can be assessed by the value of the integrated area K/T^3.

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Oceanic Duct and its Effect on Microwave Propagation

The formation of a microwave duct over the sea has been examined in terms of a distribution of potential refractive index (refractive index independent of height in an adiabatic atmosphere) corresponding to a functional relationship originally suggested by Deacon[1] to describe the distribution of certain meteorological properties in the boundary layer. Deacon's relationship takes the stability of the atmosphere into account in terms of a profile index, β, which is a function of air–sea temperature difference and wind velocity.

The resulting profiles of potential refractive index are then related to the trapping of microwaves by

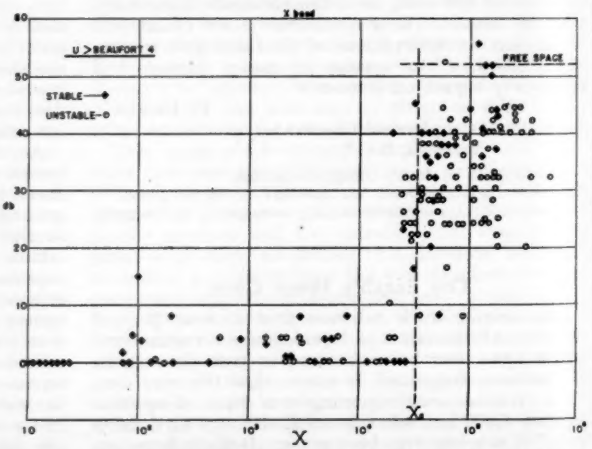

Fig. 1. Field-strength in db. above 1 microvolt/metre, vs. X, X-band, wind > 15 m.p.h.

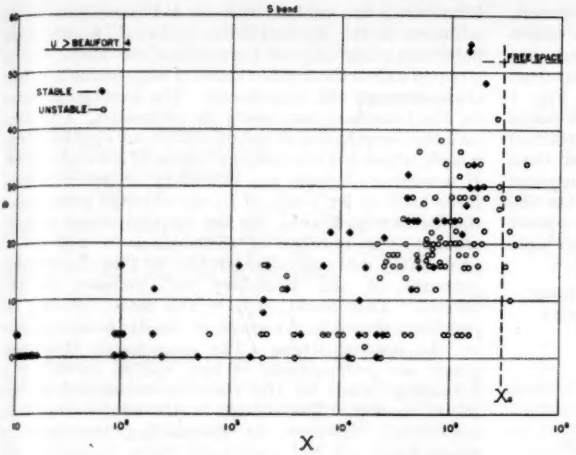

Fig. 2. Field-strength, vs. X. *S*-band, wind > 15 m.p.h.

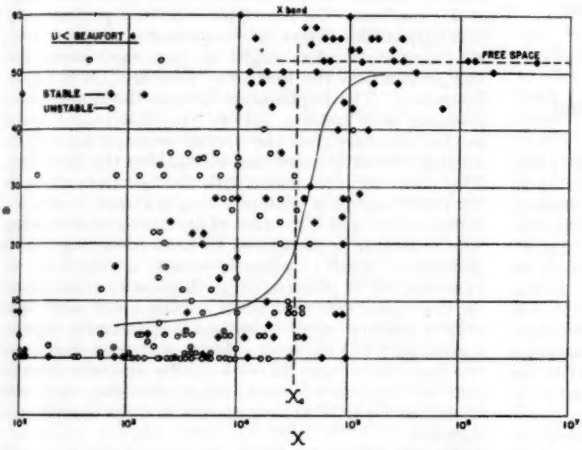

Fig. 3. Field-strength, vs. X. *X*-band, wind < 15 m.p.h.

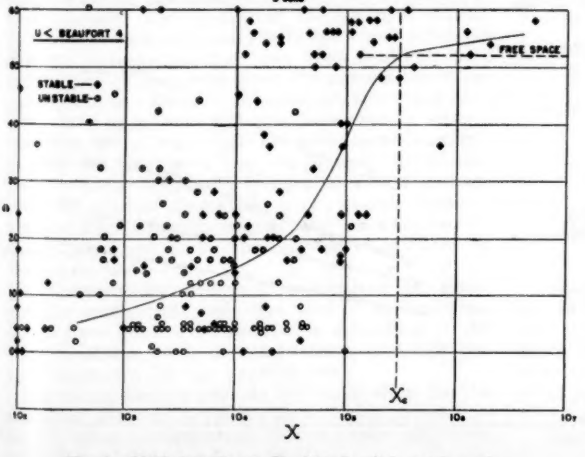

Fig. 4. Field-strength, vs. X. *S*-band, wind < 15 m.p.h.

use of a technique due to Schelkunoff[2], in which a given profile is replaced by two layers each of constant modified refractive index in such a way that distributions of radio field-strength are virtually unchanged.

These operations lead to a criterion for trapping in terms of meteorological parameters. Calling this criterion X, we obtain :

$$X = \left[\frac{(3-\beta)\,(\beta-1)}{0{\cdot}06\;\;(2-\beta)} \left(\frac{(n_1-n_0+h_1/5R)\times 10^6}{h_1^{1-\beta}-z_0^{1-\beta}}\right)\right]^{3/\beta} \frac{\beta}{3-\beta}$$

where n_1 and n_0 are index of refraction at h_1 and sea surface respectively ; β is profile index of the potential refractive index distribution ; h_1 is height at which meteorological measurements are taken ; z_0 is a parameter of surface roughness ; and R is radius of the earth.

When X exceeds 3,770 λ^2 (where λ is the wave-length in cm.), trapping should occur.

Results obtained at Cardigan Bay in the Irish Sea were kindly loaned to us by Dr. J. S. McPetrie and were analysed in terms of the criterion indicated above. Since the antenna heights were 97 ft. (much too high to take full advantage of the oceanic duct) considerable scatter is to be expected. However, it was hoped that the results would be adequate to determine whether the effects of stability could explain two aspects of the Cardigan Bay data about which considerable discussion has arisen. These are : (1) the fact noted by Jones[3] that high signals are usually associated with high wind speeds when negative air–sea temperature differences are present ; (2) the tendency noted by McPetrie and Starnecki[4] for high signals to be associated with large positive air–sea temperature differences.

It is believed that the present model adequately explains both of these points in terms of the manner in which Deacon found the parameter, β, to vary with stability. Thus, it is seen that : (1) Figs. 1 and 3 show that a far higher percentage of the unstable cases exceed the critical when high winds are observed than when low winds are present ; (2) Figs. 3 and 4 (the cases when wind velocities are low and stability is thus relatively more important) show that relatively many more stable (positive air–sea temperature difference) than unstable cases give a X which exceeds the critical value required for trapping. While the cases of low wind velocity show a great deal of scatter, this tendency seems rather definite.

These two features, coupled with the good agreement between observation and theory shown by Figs. 1 and 2, strongly indicate that the suggested model, which takes atmospheric stability into account, properly describes the processes involved.

The large scatter at low wind velocities is probably due to a variety of causes such as summer-time subsidence inversions,

path inhomogeneities, and, perhaps most important, the extrapolation of meteorological readings taken over land to over water conditions when winds are very light. On the whole, however, the median lines show that the tendency so definite in Fig. 1 is still present in Figs. 3 and 4 though obscured by some other factor or factors. The predicted break in X is generally sharper on the X-band than on the *S*-band, as might be expected, and appears to occur much nearer its theoretical value. On the other hand, the *S*-band appears to break sooner than anticipated, and to 'feel' the duct some time before it is actually trapped.

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Jan. 15.

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Interaction between Crystal Slip and Grain Boundary Movement

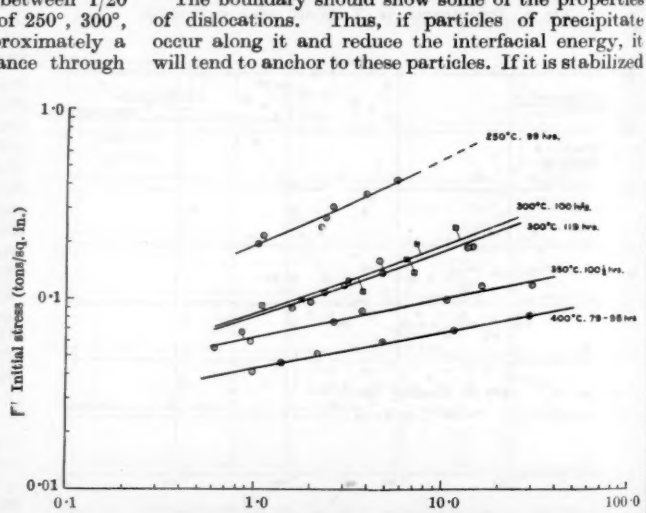
Several workers have shown that when polycrystalline metals are made to creep, that is, to deform at an elevated temperature, the grain boundaries move in a direction more or less perpendicular to themselves, just as when grain growth occurs[1]. This is migration of the boundaries, as distinct from the sliding movement, which also occurs during creep, of one grain past another. Some recent measurements show that the amount of movement is a function of the applied stress. An explanation of this is put forward here which involves an interaction between crystal slip and movement at boundaries.

Aluminium specimens were allowed to creep at (longitudinal tensile) stresses ranging between 1/20 ton and ¼ ton/sq. in. at temperatures of 250°, 300°, 350° and 400° C., in all cases for approximately a hundred hours, and the average distance through which the grain boundaries migrated was measured. The results are plotted against applied stress for each temperature in the graph. At any of these temperatures the amount of migration depended very sensitively on the magnitude of the applied stress. The sensitivity was, in fact, large enough to be quite obvious from simple micro-examination. It seems fair to conclude that virtually all the migration was caused by the applied stress, and that the amount due to surface-tension forces, which is another possible cause, was negligible.

The following situation must develop at a boundary during deformation. Dislocations approaching the boundary will experience a force tending to halt them. The boundaries will experience the equivalent opposite force. At high enough temperatures the boundaries are mobile and should move under the stimulus of the applied force, although at low temperatures when they are immobile, dislocations will be stopped unless the applied stress is large enough to force them through the boundaries. The average pressure on the boundary can easily be estimated. The force on 1 cm. length of dislocation due to an applied stress σ is σb, where b is the Burgers vector of the dislocation. If a section through the boundary shows n dislocations held up by 1 cm. of it, the average pressure on the boundary is $n\sigma b$. As the applied stress σ is increased, the number of dislocations n will in all probability increase considerably, so that the average pressure on the boundary will increase on two counts. This could explain the rather strong dependence shown in the graph of the distance migrated on the applied stress. The remarks in this paragraph are independent of any special model of a boundary, such as the dislocation model[2] or the island model[3]. The details of the model would be important, however, in calculating the rate of migration.

At this point there may seem to be a contradictory state of affairs. The stress around an edge dislocation is not uniform. On the upper side of a positive edge dislocation the stress is compressive, on the lower side tensile; and it might at first sight seem that this contradicts the idea of a 'pressure' on the grain boundary. The explanation is that the non-uniform pressure and tension act on the individual *atoms* in the boundary, but the overall pressure acts on the *arrangement* of atoms which constitutes the boundary. This distinction coincides with the fact that when the boundary moves a relatively long distance, individual atoms move only a fraction of an interatomic spacing. The situation is analogous to that occurring with a dislocation itself; when a stress is applied, for example, to a positive edge dislocation, the atoms on the upper side and those on the lower side move only a fraction of an interatomic spacing in opposite directions; but the arrangement of atoms constituting the dislocation may move a relatively large distance and be capable of overcoming obstacles, and may therefore be said to experience a force impelling it forward.

The boundary should show some of the properties of dislocations. Thus, if particles of precipitate occur along it and reduce the interfacial energy, it will tend to anchor to these particles. If it is stabilized



by segregation to it of solute atoms, migration will be hindered if the rate of diffusion of the solute atoms is low, just as with an 'atmosphere' around a dislocation.

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Score Resistance of Bearing Metals

Score resistance is the property of a bearing that enables it to resist welding to its journal. Although it is a property of the greatest technical importance, knowledge of score resistance has for many years been largely empirical, and efforts to relate score resistance to other more readily definable properties have met with only limited success.

In studying the performance of a large number of bearing metals, we have found that the good bearing metals are those which at their melting points have extremely limited solid solubilities in iron. Thus, lead, tin, indium, thallium and cadmium have excellent score resistance and negligible solubility in iron. Copper, gold, platinum and nickel, on the other hand, have poor score resistance and large solubility in iron. Silver, zinc and aluminium are intermediate as regards both score resistance and solubility in iron. The more dissimilar two metals are, the greater will be their score resistance when rubbed together. Specifically, the metals should be dissimilar with regard to, first, crystal binding forces and, secondly, atomic sizes. The former factor is most readily described in terms of the periodic classification of elements, as was pointed out by Underwood[1]. Thus, the main journal metals (iron, nickel, chromium, manganese, vanadium and molybdenum) are all transition metals with strongly metallic binding. These, as well as metals (such as copper and gold) which immediately follow transition groups in the periodic classification, have poor score resistance when used as bearing metals in conjunction with steel journals. The *B*-subgroup metals (such as lead, tin, indium, cadmium and thallium), which have less strongly metallic binding, have been found to have excellent score resistance when run against transition metal journals. Exceptional cases are silver and zinc. Silver is a metal which occurs immediately after a transition group but which has unfavourable atomic size for alloying with iron (as defined by Hume-Rothery[2]) and technically acceptable score resistance when run against steel. Zinc is two atomic numbers removed from a transition group but has a favourable atomic size and is an undesirable constituent of bearing metals.

The essentially non-metallic binding of intermetallic compounds indicates that such materials should have good score resistance, regardless of the score resistance of their constituents, and this has been borne out by our experiments.

The above factors provide an explanation for the anti-score characteristics conferred upon metal surfaces by films of compounds such as oxides, chlorides, sulphides, selenides and the like.

A more complete account of these and other aspects of score resistance will be published elsewhere.

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Hydrolysis of Organic Nitrites

In continuation of investigations into the mechanisms of reactions of organic esters[1], a study has been made of the hydrolysis of some simple organic nitrites. It was known[2] that the acid-catalysed hydrolysis of these esters is very rapid at room temperature, while the rate of reaction in alkaline media is comparatively slow.

Acid catalysis. The hydrolysis of *n*-propyl, *tert.*-butyl and benzhydryl nitrites has been studied at 0° C. in 72·5 per cent dioxan-water (by weight) as solvent in the presence of small concentrations of mineral acids. Kinetics observed were of the first order with respect to the nitrite concentration, and with perchloric acid as the catalyst the first-order constants are directly proportional to the acid concentration over the range 0·001–0·007 *M*, wherein the reaction proceeds at a convenient speed. For a fixed hydrogen ion concentration, and at constant ionic strength, a further marked catalysis was observed on addition of chloride and bromide ions, the increase in rate being proportional to the halide concentration up to 0·012 *M*. The results may be interpreted as follows:

$$RONO + H^+ \overset{\text{fast}}{\longleftrightarrow} (RONOH)^+$$

$$(RONOH)^+ + H_2O \overset{\text{slow}}{\longleftrightarrow} ROH + (H_2ONO)^+$$

$$(RONOH)^+ + X^- \overset{\text{slow}}{\longleftrightarrow} ROH + NOX \ (X = \text{Cl, Br}).$$

Omitting the concentration of water, since this is in large excess, the expression for the rate becomes:

$$-\frac{d(RONO)}{dt} = k_2(H^+)(RONO) + k_3(H^+)(RONO)(X^-).$$

Values of k_2 and k_3 are:

	k_2 (sec.$^{-1}$ gm. mol.$^{-1}$ l.)	k_3 (for X = Br) (sec.$^{-1}$ gm. mol.$^{-2}$ l.^{2})
n-Propyl nitrite	0·218	26·8
tert.-Butyl nitrite	0·526	8·9
Benzhydryl nitrite	0·19	27

Alkaline catalysis. The hydrolysis of *n*-propyl and *tert.*-butyl nitrites by sodium hydroxide in 60 per cent dioxan-water has been studied over the temperature range 25–55° C. Good second-order kinetics were observed, and the rate constants are found to be in accordance with the usual relationship:

$$\log_{10} k_2 = \log_{10} A - \frac{E}{2{\cdot}303\,RT}.$$

The following values of $\log_{10} A$ and E were calculated, the units of A being sec.$^{-1}$ gm. mol.$^{-1}$ litres :

	k_2 (35°)	E (k.cal.)	$\log_{10} A$
n-Propyl	$7{\cdot}6 \times 10^{-4}$	17·5	8·31
tert.-Butyl	$13{\cdot}2 \times 10^{-7}$	20·6	8·75

The neutral solvolytic reaction under these conditions is very slow, the rate coefficient for *n*-propyl nitrite, for example, being not greater than $1{\cdot}5 \times 10^{-6}$ sec.$^{-1}$ at 35° C.

Position of bond fission. It is known[3] that the pyrolysis of alkyl nitrites occurs by the fission of the nitrosyl oxygen bond, *R*O—|—NO. The ester exchange reaction between *l*.-2-octyl nitrite and *sec*.-butyl alcohol has been found[4] to produce optically pure *l*.-2-octyl alcohol. In the present work complete retention of configuration has also been observed for the esterification of *l*.-2-octyl alcohol with nitrous acid in water, and for the subsequent hydrolysis of the ester in dilute acid and in alkaline media. Thus it is evident that, for this ester, the nitrosyl–oxygen bond alone is broken over the whole range from dilute acid to dilute alkaline conditions.

Experiments in which *n*-propyl and *tert*.-butyl nitrites were dissolved in their respective alcohols, sealed, and kept at 35° C. for many weeks, showed complete absence of the formation of ether which would have resulted from any small percentage of alkyl–oxygen bond fission.

The absence of carbonium ion formation in the acid-catalysed hydrolysis of *tert*.-butyl nitrite under kinetic conditions has been shown by the complete absence of any formation of olefin, and also by experiments in the presence of water enriched with $H_2{}^{18}O$. At the end of the reaction, the *tert*.-butyl alcohol isolated was found to be of normal isotopic composition.

Within the range of structural and environmental conditions examined, it is probable that the rate-determining stage consists of the attack of a nucleophilic reagent on the nitrogen atom of the ester (alkaline hydrolysis) or of the protonated ester (acid hydrolysis) ; but we cannot exclude the possibility of other mechanisms under other conditions, particularly one which is related to the mechanism now put forward, as S_N1 is related to S_N2. Further investigations are in progress with other organic nitrites under various conditions.

A full account of this work will be published elsewhere. Acknowledgment is made to Prof. E. D. Hughes and Prof. C. K. Ingold for advice and encouragement, and to Drs. C. A. Bunton and D. R. Llewellyn for their collaboration in the experiments with isotopically enriched water. Much of this work was made possible by the provision of a maintenance grant by the Ministry of Education.

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Deoxyribonucleic Acid Content of the Germinal Vesicle of the Ovocyte in *Fasciola hepatica*

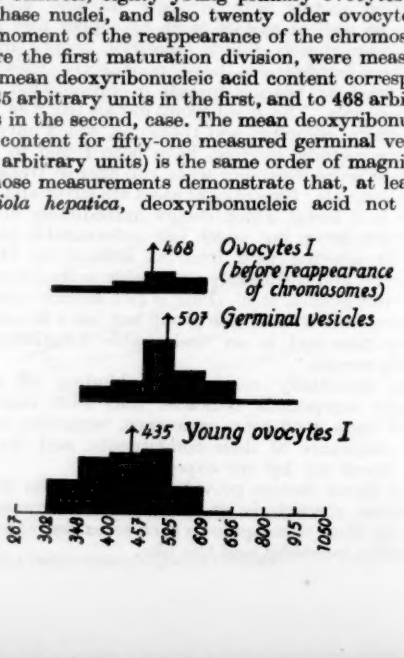
Since deoxyribonucleoproteins possibly constitute a substratum of the genome, the problem of the permanent character of deoxyribonucleic acid in the cell nucleus is of much present interest, and especially in the elements of the germinal lineage. However, it is known that in the nucleus of the primary ovocyte, after it swells to form a germinal vesicle, Feulgen's reaction becomes negative, or in some species very slightly positive. J. Brachet[1] demonstrated by means of centrifugation that, even in the cases of negative Feulgen's reactions, deoxyribonucleic acid is present in the germinal vesicle, but too dilute to give a visible re-coloration of the fuchsin : after centrifugation, a centrifugal cap of the acid was detected even in cases of negative reaction. The permanent character of the deoxyribonucleic acid was also qualitatively demonstrated in the germinal vesicle ; but the quantitative aspect of the problem remains, so far as we know, still an open question.

In *Fasciola hepatica*, the germinal vesicle contains a nucleolus surrounded by 'nucleolar associated chromatin' and a network of extremely thin Feulgen-positive filaments. Their distribution is homogeneous enough to permit quantitative valuations of the deoxyribonucleic acid content by means of the histophotometrical method of L. Lison[2]. The animals were fixed whole in Carnoy's liquid. To ensure a uniform Feulgen reaction throughout the whole experiment, only nuclei contained entirely in a section of the same slide were compared. No attempt was made to calculate absolute amounts, and the reported figures have only relative values.

The results are brought together in the accompanying histogram. The relative amounts of deoxyribonucleic acid are plotted logarithmically on the abscissæ, and the relative frequencies of the classes comprised between two successive figures of the horizontal scale are plotted as ordinates.

As controls, eighty young primary ovocytes with prophase nuclei, and also twenty older ovocytes, at the moment of the reappearance of the chromosomes before the first maturation division, were measured. The mean deoxyribonucleic acid content corresponds to 435 arbitrary units in the first, and to 468 arbitrary units in the second, case. The mean deoxyribonucleic acid content for fifty-one measured germinal vesicles (507 arbitrary units) is the same order of magnitude.

Those measurements demonstrate that, at least in *Fasciola hepatica*, deoxyribonucleic acid not only



persists, but also remains quantitatively constant in the germinal vesicle.

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Complex Reactions of Cytochrome *c*

DURING measurements of the time course of reduction of the cytochrome system of living wheat roots (cf. ref. 1), it was observed that the γ-band at λ 418 of *c* develops considerably slower than the corresponding α-band at λ 550 mμ. The wheat roots are provided with a complete cytochrome system, the prosthetic groups of which correspond to the cytochromes *a* (cytochrome oxidase), *c* and *b*. Before *b*, a fourth component, probably identical with succinic dehydrogenase, acts as the source of electrons. This component has a strong band at 570–575 mμ.

At normal aeration the cytochromes maintain a high degree of oxidation, amounting to 64–84 per cent of the total quantities. With cessation of oxygen supply the steady states are moved in direction of complete reduction. Because the root tissue holds certain quantities of oxygen, this process proceeds gradually in a few minutes, the time course thus enabling a fairly accurate recording of the single bands. It was now observed that the increase of the Soret bands and α-bands of *a* and *b* run approximately synchronously. Averages of six readings resulted in a half time (= from aerobic oxidation to 50 per cent remaining reduction) of 266 sec. for *b*γ (λ 427 mμ), and 272 sec. for *b*α (λ 562 mμ). Because the reduction of the cytochrome oxidase runs considerably faster than that of *b* (see ref. 2) no accurate values are hitherto available concerning this cytochrome. But the time curves show no pronounced discrepancies between *a*γ and *a*α. As to cytochrome *c*, however, the development of the reduced Soret band shows a great lag of time as compared with the α-band. An average of six series rendered the half-time values 250 sec. for the Soret band but only 65 sec. for *c*α.

The results point to the interference of a complex reaction between cytochrome *c* and a substrate. Because the spectrograms of *a* and *b* do not reveal a corresponding disturbance, it seems unlikely to surmise compounds between the cytochromes themselves. The idea of an intermediate catalyst between *c* and *b* has now been presented by Slater[3], and it may be tentatively assumed that such an intermediate factor serves as the substrate of oxidized cytochrome *c*, resulting in a complex $c_{ox} \times factor_{red}$. This complex undergoes oxido-reduction to $c_{red} \times factor_{ox}$. Dissociation of the complex is brought about either by oxidation of c_{red} by cytochrome oxidase, or by reduction of $factor_{ox}$ by cytochrome *b*. The scheme explains why so little of the complex is noticed at normally working aerobic respiration. At inhibited cytochrome oxidase a comparatively large quantity of the complex will be immediately formed and, at increasing anaerobiosis, slowly decomposed by *b* and the dehydrogenase, synchronously with the reduction of both *c* and the factor. Work is in progress bearing on the calculation of the equilibrium constants.

The strong depression of the Soret band of cytochrome *c* in the complex reaction is reminiscent of the enzyme-substrate compounds of peroxidase[4].

Attention is directed to the fact that the hæmatin of cytochrome *c* is closely related to that of peroxidase.

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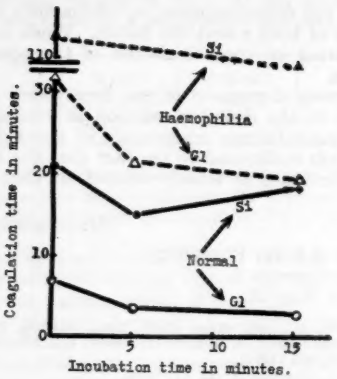
Formation of Thromboplastin in Shed Mammalian Blood

A NUMBER of substances are available to maintain the fluidity of blood outside the organism. It is usually assumed that the addition of the anticoagulants does not produce any change of the blood components involved in the clotting process. However, if after the addition of adequate quantities of citrate to blood, the cellular elements are removed and the calcium ion concentration is re-established in the separated plasma, then coagulation of the plasma will occur generally in a far shorter time than in blood which is allowed to clot without interference. It appears that some activation occurs during the isolation procedure.

In order to obtain information on this activation process, it was thought desirable to carry out experiments with whole blood, and thus obviate influences due to change in the cellular composition, and to handling. Venous blood was collected from humans, first with glass and then with silicone-coated syringes. ('Silicone Dri Film 9987', General Electric, was used.) Measured volumes of blood were distributed into both glass and silicone-coated coagulation tubes, maintained at 37° C. The arrangement was as follows: (*a*) Whole blood coagulation time was determined in 1·5-ml. aliquots. (*b*) In a further series, the tubes contained 0·55 ml. of 0·15 *M* sodium chloride solution to which 1 ml. blood was added. (*c*) In a third series, 1 ml. blood was added to 0·55 ml. of a solution containing 0·037 *M* tri-sodium citrate, 0·06 *M* sodium chloride and 0·046 *M* calcium chloride. (*d*) 1 ml. blood was added to 0·4 ml. of a solution containing 0·051 *M* tri-sodium citrate, and 0·082 *M* sodium chloride. This series was incubated for varying times before 0·15 ml. of 0·16 *M* calcium chloride was added. The setting up of the four series required approximately one minute. The experiments were carried out with blood specimens taken from eleven normal human donors, and from six hæmophiliacs.

A summary of the results of the experiments is given in the accompanying graph.

From these results it is apparent that normal human blood incubated with sodium citrate in glass tubes (curve Normal *Gl*) for periods up to 15 min. clots on recalcification in an average time of 2·5 min. (varying from 1·5 to 3·5 min.), which compared with the starting value of 7 min. (varying from 4 to 10



Coagulation-time of whole blood after incubation with sodium citrate in wettable or water-repellent tubes

min.) represents a considerable acceleration. On the other hand, treatment of normal blood in contact with a siliconized tube (curve Normal Si) showed an initial drop of the coagulation time[1], but little further change occurred during the incubation period. Blood from hæmophiliacs behaved less uniformly than normal blood. According to the type of deficiency, incubation in glass resulted in either shortening or no change in clotting time, while when in contact with a siliconized surface in no case was a difference between start and end values observed. The significance of these observations will be discussed more fully elsewhere.

Since several workers connect the thrombocytes with the supply and activation of clotting components, thrombocyte counts[2] were carried out simultaneously with coagulation experiments.

Statistical evaluation of the counts indicated that incubation of citrated blood at 37° C. for 15 min. did not produce a significant change in the number of thrombocytes ($t = 0{\cdot}75$, d.f. $= 38$; for $P = 0{\cdot}01$, $t = 2{\cdot}58$). Regarding other means of maintaining fluidity of the shed blood, it appears that application of cation exchange resins to remove calcium ions does not prevent acceleration of coagulation because of the surface properties of the resins. The addition of heparin to blood in contact with 'Pyrex' glass was also found to be of limited value, despite the fact that adequate amounts of heparin were added. Addition of salmine sulphate to abolish the heparin effect resulted in shortening of the coagulation time of whole blood. Finally, addition of ethylene diamino-tetra-acetate to whole blood in 'Pyrex' glass to give a concentration of 0·2–0·5 per cent resulted in a marked delay of the coagulation time following the addition of excess calcium ions. This apparently strong antithrombin effect of diamine-tetra-acetate[3,4] masks other reactions. If it is desired to obtain unmodified blood with regard to the clotting factors, it is necessary to collect blood in containers with surface properties similar to that of the silicones. The addition of citrate or oxalate is permissible.

The results reported are consistent with the assumption that normal blood plasma contains a soluble precursor of the thromboplastin complex[5,6,7], which in contact with glass at calcium ion concentration as low as 10^{-5} *M* becomes activated. This seems to be the first step in the chain of the clotting process. No breakdown of platelets occurs during that phase. It is very likely that the glass surface acts as a kinase activating the precursor prothromboplastin to thromboplastin.

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Anti-Diuretic Substances of the Blood

The intraperitoneal injection of either human serum or plasma (0·5–1 ml. per 100 gm. of body-weight) inhibits urinary excretion of hyperhydrated rats. This effect disappears when either serum or plasma is dialysed against running water for 12–24 hr. Incubation at 37° C. during a period longer than eight hours destroys practically all the anti-diuretic potency of serum provided that bacterial contamination is avoided[1].

The blood serum of pregnant women shows a progressive anti-diuretase enzymatic activity, that is, the power to destroy the pressor and anti-diuretic effect of vasopressin when the latter is added. During the ninth month of pregnancy, 0·1 ml. of serum destroys from 300–350 mU. of vasopressin in a period of 40–50 min. This is rather surprising since it has been calculated that the hypophysis liberates an amount of anti-diuretic hormone equivalent to 1–5 mU. per hr.[2]. The serum obtained from a pregnant woman and injected into the rat (Burn's test[3]) has, however, greater anti-diuretic potency than serum from a non-pregnant woman (Fig. 1). Dialysis performed in a cellulose tube decreases similarly the anti-diuretic potency of serum from pregnant and non-pregnant women. Incubation at 37° C. of serum obtained during pregnancy inactivates its anti-diuretic substances; but the inactivation follows a time course which is similar for pregnant and non-pregnant women, in spite of the fact that the former has greater anti-diuretase activity (Fig. 1).

It seems evident that the presence of vasopressin would not explain by itself the anti-diuretic effect of serum. Apparently enteramine[4] may be disregarded because neither dibenamine nor dihydrocornine neutralizes the anti-diuretic action of serum when injected in rats (Burn's test).

In five patients suffering from diabetes insipidus, it has been possible to demonstrate that the anti-diuretic potency of their serum is no different from serum of normal individuals[5]. In this case Burn's test was also used.

Careful analysis of these results indicates that the anti-diuretic effect of serum, evaluated by the Burn's test, may be caused by the action of two substances present in the serum : (*A*) free anti-diuretic hormone,

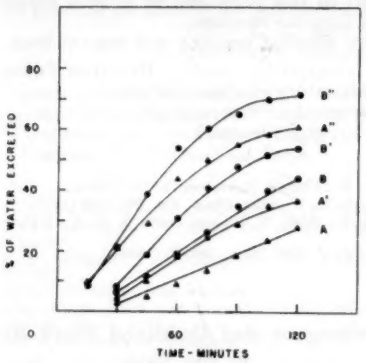

Fig. 1. Each curve represents the percentage of urinary excretion of 80 hyperhydrated rats (Burn's test). The following intraperitoneal injections expressed in 100 gm. of body weight were given:
A, 0·5 ml. of serum obtained from women in the ninth month of pregnancy, kept at − 5° C. up to moment of the injection; samples of 20 women.
B, 0·5 ml. of serum obtained from non-pregnant women and also kept at − 5° C.; samples of 20 women.
A', as *A*; sera incubated at 37° C. during 4 hr.
B' as *B*; sera incubated at 37° C. during 4 hr.
A'', as *A*; sera incubated during 8 hr.
B'', as *B*; sera incubated during 8 hr.

probably vasopressin; and (*B*) a substance similar to the latter which may be loosely linked to a protein and which would have no physiological effect unless liberated from this protein. Substance *A* would be present in small quantities in the blood and would be easily destroyed by anti-diuretase enzyme; therefore, its action would disappear rapidly from the serum of pregnant women. Substance *B* would be protected from enzymatic activity while linked to a protein; after prolonged dialysis of serum it would be liberated and thus eliminated. Serum probably contains a larger proportion of substance *B* than substance *A*.

When the Burn's test is carried out, the rat shows the effect of substances *A* and *B*. The latter is inactive in the donor's blood while linked to the protein; it is liberated and then activated as soon as it is injected into the peritoneum of the recipient rat. Because substance *A* is present in very small quantities, and furthermore is rapidly vulnerable to enzymatic action, the intensity of the anti-diuretic effect is mainly due to substance *B*.

When serum has been dialysed, it loses its anti-diuretic effects and it has neither *A* nor *B* factors; nevertheless, by adequate treatment with pepsin (*p*H 2·5–3·5) it liberates a peptide which has similar properties to vasopressin[6]. This forms another fraction (fraction *C*) which, like fraction *B*, is linked to a protein; but in order to liberate it, great disintegration of the protein molecule is necessary. The anti-diuretic effects of fraction *C*, which resembles vasopressin, are not inhibited either by dibenamine or dehydroergocornine. The probable distribution of these fractions is summarized in Fig. 2.

We wish to thank the Rockefeller Foundation and the Fundacion Gildemeister for research grants which made this work possible.

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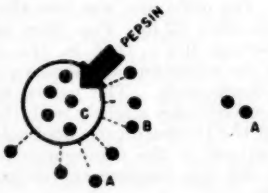

Fig. 2. Distribution of anti-diuretic substances in serum.
A: less abundant than *B* and *C* even in normal subjects, represents the free and active fraction, that is, the anti-diuretic hormone (vasopressin?); easily inactivated by enzymes (antidiuretase) and dialyses rapidly.
B: This fraction and *C* are linked with proteins, and present in the blood in larger quantities than *A*. Inactive while linked. *B* is loosely linked and easily liberated and transformed in the active hormone.
C: This fraction is strongly linked to proteins. It is not liberated by dialysis or inactivated after incubation of serum (37°). It is liberated only after deep hydrolysis of proteins (peptic digestion, *p*H 2·5–3·5). The circle represents the molecule of protein; the arrow the destruction of this molecule, which allows the liberation of fraction *C*

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Enzymatic Hydrolysis of Xylan

A previous investigation[1] has shown that enzymes from *Chætomium globosum* are able to hydrolyse wheat straw xylan to xylose with the formation of a series of intermediates, designated *a,b,c, . . . g*, which appear on paper-chromatograms with regularly decreasing R_F-values, and which are believed to be oligosaccharides with regularly increasing xylose units: xylobiose[2], xylotriose, xylotetraose . . . etc. By heating or storing the enzyme preparations, it was possible to arrest the hydrolysis at the xylobiose stage, indicating that two enzymes are present, (*A*) hydrolysing the xyloside chain to xylobiose and (*B*) hydrolysing xylobiose to xylose.

The investigation has been continued with a *Streptomyces* sp. and a *Micromonospora* sp. isolated from compost, a *Cellvibrio* sp. isolated from soil by Dr. H. L. Jensen, and *Chætomium globosum*. The organisms were grown on media containing 0·5 per cent xylan in a colloidal solution as source of carbon. Culture filtrate and acetone-dried cell material were used as enzyme sources.

Intermediates. Determinations of constituent sugars in intermediates were carried out by paper-chromatography (three different solvents, development for 40 hr.) after acid hydrolysis of the intermediates extracted from paper sheets[3]. From the accompanying table it is seen that intermediate *a* and *b* yielded xylose only. In intermediate *a* the ratio of reducing sugar[4] after and before hydrolysis was found to be approximately 2, indicating the disaccharide xylobiose[2]. The same ratio for *b* was found a little less than the theoretical value for a trisaccharide (probably because of the small amounts subjected to acid hydrolysis and sugar determinations); but enzymatic hydrolysis (see below) of *b* yielded xylose and xylobiose in equal concentrations, and it is concluded that *b* is xylotriose[2].

Sugars Found after Acid Hydrolysis of Intermediates resulting from Enzymatic Hydrolysis of Xylan or Mild Acid Hydrolysis of Wheat Straw

Intermediates	R_F*	Hydrolysates enzymatic	Hydrolysates acid	Constituent sugars†
a	1·0	+	+	Xylose
I	0·84	+	−	Xylose, arabinose
II	0·77	−	+	Xylose, arabinose, galactose, (glucose)
III	0·60	−	+	Xylose, glucose, galactose, (arabinose)
b	0·38	+	+	Xylose

* In relation to *a* (xylobiose), for the solvent ethyl acetate : acetic acid : water, 9 : 2 : 2.

† Brackets indicate that the sugar is found only in traces.

Three faint spots indicating other intermediates were situated between xylobiose and xylotriose; the R_F values and constituent sugars found after extraction and acid hydrolysis are given in the table. These intermediates may originate from the polyuronide part of the xylan. During the enzymatic hydrolysis of a colloidal solution of xylan, an enzyme-resistant precipitate appeared which, after isolation and acid hydrolysis, yielded the following sugar units: xylose, arabinose, mannose, glucose, galactose, uronic acid, and a trace of rhamnose. This precipitate may represent the polyuronide part of the xylan. In the culture filtrate after growth of the organisms on media containing 0·5 per cent colloidal xylan and in the acid hydrolysate from wheat straw (see below), one or several compounds were found of which the barium salt is soluble in water but insoluble in ethanol and ether, and which after acid hydrolysis yielded the same sugars as the 'polyuronide precipitate'. Judging from the intensity of the spots on the chromatograms, the sugars were present in approximately the same concentrations, except that the barium salt of the acid hydrolysate contained very little arabinose.

Mild acid hydrolysis of powdered ether- and ethanol-extracted wheat straw yielded almost the same sugars and intermediates as found after enzymatic hydrolysis of xylan (see table). Arabinose seemed to be the first product to appear; glucose was found only in very small amounts, but galactose in somewhat larger quantities.

Culture filtrate of the *Streptomyces* sp., added to powdered and extracted wheat straw, was able to split off from the wheat straw the following sugars: xylose, arabinose, glucose, xylobiose, xylotriose and other intermediates.

Enzymatic hydrolysis of xylobiose and xylotriose. Culture filtrates or powdered acetone-dried cell material were added to the sugars prepared by extraction from paper sheets[2]. In some cases the reaction products were determined quantitatively.

Culture filtrates of *Chætomium globosum*, *Streptomyces* and *Micromonospora* were able to split xylotriose to equal amounts of xylose and xylobiose, but unable to split xylobiose to xylose, whereas the cell materials effected the hydrolysis of xylobiose to xylose. These results indicate that at least two enzymes are active in the hydrolysis of xylan—an exoenzyme (*A*) able to act on xyloside chains with three or more xylose units, and an endoenzyme (*B*) which is able to split xylobiose. Consequently, the specificity appears to depend on something related to molecule-size or chain-length of the substrate.

Culture filtrates and cell material of the *Cellvibrio* sp. were both able to split xylotriose and xylobiose to xylose; but it is not yet known if only one enzyme is present in this organism, or if both enzymes are excreted into the medium.

A more detailed account will appear later.

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Carcinogens and Oxidized Fatty Acids in the Skin

Rusch and Kline[1] showed that carcinogenic hydrocarbons inhibit the autoxidation of unsaturated fatty acids. Thiobarbituric acid is a reagent for the estimation of fatty acid peroxides[2,3] and has been used for confirming the inhibition of the autoxidation of fatty acids, in particular linolenic acid, by these compounds. Pieces of excised skin placed in thiobarbituric acid give the characteristic red colour produced by the reaction of this acid with oxidized fatty acids[3]. Various carcinogens were painted on the skin of white mice to determine their effect on the peroxide concentration *in vivo*. Previous experiments have shown that the carcinogens inhibited the peroxide formation in homogenates of brain and skin. The compounds themselves do not interfere with the thiobarbituric acid reaction.

The hair was clipped from both flanks, and care was taken not to injure the epidermis. To one flank, one of the following compounds was applied: 3,4 benzpyrene, 20-methyl cholanthrene, and chrysene in a concentration of 0·3 per cent in benzene, 2-aminofluorene and 2-nitrofluorene in a concentration of 2 per cent in acetone. To the other flank, the solvent alone was applied. The mice were killed at intervals, equal areas of skin excised, and placed in 0·75 per cent thiobarbituric acid at room temperature. The development of colour was estimated qualitatively at intervals for a period of 3–4 hr.

If the mice were killed immediately after the application, there was a slight decrease in intensity of colour over that of the control side. This became more striking when the mice were killed 24 hr. after application. The difference was less after 48 hr. and was negligible after 72 hr. The effect was seen only on the epidermal side; that is, the colour which developed in the subcutaneous fat was not affected by any of the compounds. The yellow colour of the fluorenes interfered only slightly with the qualitative estimation of the thiobarbituric acid colour. Several daily applications of the compounds before killing the animals did not increase the differences in the 24-hr. values.

Five carcinogens were found to inhibit colour development to approximately the same extent. (Stilbœstrol, used as a control, had no effect.) Since they differ markedly in their carcinogenic activity[4], the inhibition they produce in fatty acid oxidation may be a necessary, but certainly is not a sufficient, condition for tumour production. It may be pointed out that oxidized fatty acids are more effective inhibitors of certain enzymes[5] and of bacterial growth[6] than the corresponding unoxidized acids.

Thus the carcinogens, by inhibiting peroxide formation, may produce conditions favourable for growth.

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Precipitins to Grass Pollen Proteins

THE skin-reactive substances of grass pollen extracts used in clinical allergy have recently been shown to be proteins of average molecular weight 14,000[1]. Only two instances of a precipitating antiserum to grass pollen extracts are known[2,3].

In the present investigation, the isolated protein components themselves were employed in experiments with rabbits and guinea pigs, aluminium phosphate[4] and tubercle bacilli[5] being used as adjuvants. Precipitin formation occurred in six out of seven rabbits and in all five of the guinea pigs injected.

Phleum pratense (timothy grass) and *Dactylis glomerata* (cocksfoot or orchard grass) pollen proteins were used as the immunizing antigens in doses varying from 50 to 400 mgm. per animal over periods from five weeks to several months. Injections were given subcutaneously or intramuscularly. At an antiserum dilution-level of 1/4, optimum flocculation points were within the antigen-range of 0·01–0·004 gm. pollen protein/100 ml., ranges of 0·1–0·000001 gm./100 ml. being tested. These are maximum figures, since none of the antigens used can be regarded as pure. The testing antigens were crude and purified pollen extracts of *Phleum pratense*, *Dactylis glomerata*, *Festuca pratensis* (fescue) and *Cynodon dactylon* (Bermuda grass). All the antisera and antigens were cross-reacting; but the amount of precipitate formed appeared to depend upon the degree of botanical relationship between the grasses.

Timothy pollen proteins have been fractionated into active albumins and globulins[6]. The globulins only were found to precipitate readily with the antisera to the unfractionated complexes. Accordingly, the supernatants from these antigen–antibody complexes were active throughout the testing range when used for skin (prick) tests on allergic subjects. At the optimum flocculation point, the activity in the supernatant was most probably due to uncombined pollen–albumin. The antigen–antibody complexes were washed vigorously with cold sterile saline. Even after repeating the process six times, positive skin reactions were obtained with the flocculates dissolved in the minimum of 0·1 *N* sodium hydroxide.

It seems thus, that in timothy at any rate, precipitin formation is due to at least one of the skin-reactive proteins.

Work is in progress to put the precipitin reactions on a quantitative basis, with the view of standardizing pollen extracts for clinical purposes in the treatment of asthma and hay fever.

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A Source of Amniotic Fluid in the Lamb: the Naso-Pharyngeal and Buccal Cavities

INVESTIGATIONS in recent years have shown that there is an exchange of water between amniotic fluid and the blood streams of the mother and fœtus. This has been observed in the guinea pig[1] and human[2]. In the latter, a volume of water equal to about one-third the total volume of amniotic fluid is exchanged every hour from the twenty-eighth week to term[2]. At present, there is neither a set of observations nor a hypothesis to account for such a rapid and voluminous turnover of water, and no one has shown by what route or routes this fluid is derived.

During January to March 1953, extended observations in this laboratory were made on the reflex control of the circulation of the fœtal lamb. A total of twenty-eight fœtuses ranging in age from 110 days to term (149 days) were used. Most fœtuses survived from one to four hours. During an experiment, the fœtuses were delivered from ewes under 'Dial-urethane' anæsthesia by Cæsarean section. Breathing of the lamb was prevented, with the placental circulation maintained, by applying a rubber nose-bag (condom) over the head of the fœtus before it could breathe. This technique is like that used by Barcroft and Barron (see ref. 4), by Barclay, Franklin and Prichard[5] and others. Before the nose-bag was applied, a small amount of amniotic fluid was placed in it.

In these experiments, we have been repeatedly impressed with the large volume of fluid accumulating in the nose-bag during the period of experimentation. The fluid is clear as water; but it contains a considerable amount of viscous material, quite clearly mucous in character. In the last two experiments, the volume of this accumulation was measured. The lambs were twins, weighing 2·3 kgm., estimated by weight to be about 120 days gestation age. In one experiment, 37 c.c. of fluid was added to an initial volume of 30 c.c. In the second, a volume of 29·5 c.c. was added.

The conditions of the first experiment were essentially as follows: the fœtus was subjected to bilateral stellate ganglionectomy, with section of the third and fourth thoracic sympathetic post-ganglionic fibres, cannulation of the left carotid artery and bilateral adrenalectomy. A severe hæmorrhage occurred during the last procedure. As a result, during the last part of a total period lasting 1¾ hr. the fœtus was moribund, with a blood pressure of 45/21 mm. of mercury. Despite this, the volume of fluid collected was 37 c.c.

The second fœtus survived a total of 46 min. after application of the nose-bag. During this time the left

carotid artery was cannulated, and adrenalectomy procedures (incomplete) and repeated temporary occlusion of either the two umbilical arteries or two umbilical veins were carried out. Upon removal of the nose-bag, a considerable quantity of clear, stringy fluid came from the mouth and nose of the fœtus; but it became mixed with blood on the table top, so it could not be recovered. Even so, the volume of fluid collected was 29·5 c.c.

At autopsy, Dr. G. W. Bartelmez examined the viscera of the fœtuses. He found no abnormal amount of fluid in the stomach or intestines.

During these experiments, the conditions of which were rather extreme, significant secretion of fluid occurred in the naso-pharynx and mouth. It was rich in mucin. If this fluid had passed normally into the amniotic sac, as it would have done had the fœtus been *in utero*, significant quantities of water, salt and protein would have been added to that fluid. It is possible that some fluid may have been swallowed, in the absence of ligation of the œsophagus, or have passed into the lungs, although this is unlikely since at no time were there respiratory movements. It seems clear, in any event, that secretions of the naso-pharynx and buccal cavities are a source of amniotic fluid in the lamb during the latter part of gestation.

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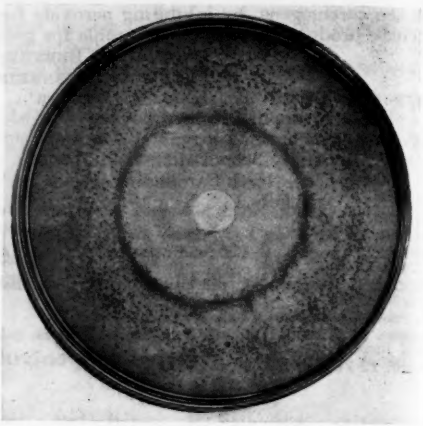
Specific Suppression by Glycine of the Phenotypic Expression of Partially Reverted Glycineless *E. coli* Mutants

The enhancement of the phenotypic expression of delayed mutations has been reported by Witkin[1]. The purpose of the present communication is to describe the suppression by glycine of the phenotypic expression of a mutant with a partial requirement for glycine. Such strains arise by partial reversion of an *E. coli* mutant which is entirely dependent upon glycine or serine[2,3]. It can be shown on solid media (where selection phenomena are limited since the cells are spatially fixed) that the growth of a partially reverted strain, as well as mutations to increasingly independent types, is suppressed in minimal medium if the strain was previously grown in the presence of glycine.

This was shown in the following way: a minimal agar plate was spread with a suspension of the partially reverted strain, the plate dried, and a drop of a glycine solution placed in a hole made in the centre of the plate. After a day's incubation, a circular area of growth appears around the region of the glycine diffusion. By the second day, however, the cells on the glycine-free medium have grown to about the same extent as the cells which have by then depleted the plate of glycine. At the end of the second day, a circle of inhibition of growth begins



in the area of previous glycine utilization. This clear, central area of the plate becomes increasingly obvious in contrast with the denser growth on the outer regions of the plate. By this time mutant colonies of more independent cell types appear over the outer portions of the plate to the extent that after about two days the new (primary) colonies almost cover the initial layer of growth—leaving the bare central area of inhibition, since mutations do not occur among the cells which had used glycine. An example of such a plate after four days incubation is shown herewith. Only secondary colonies are visible in this photograph.

Cells from various regions of the plate retain their respective characteristics when transferred to fresh minimal medium. After prolonged growth (at a very low rate) in minimal medium, it is possible for the suppressed cells to recover their potential abilities to grow at their former rate, and to mutate to increasingly independent types. The time needed for 'recovery' depends upon the extent of previous growth in the presence of glycine. The utilization of glycine only temporarily affects the heritable abilities of the cells to grow and mutate when transferred to a minimal medium; during glycine utilization and during the subsequent slow growth in minimal medium, the cells retain their potential characteristics as partially reverted bacteria. Thus the phenotypic expression of a mutant which has acquired a new ability, glycine synthesis, is suppressed by the presence of glycine prior to the growth of the mutant on a deficient medium selecting for this phenotype. In other words, glycine utilization has depressed specific biosynthetic abilities of the cell. This effect may be analogous to the depression of the ability of *E. coli* cells to synthesize methionine after growth in its presence[4,5].

Such a situation offers a mechanism, other than negative selection with respect to growth-rates, for the suppression of independent mutants in populations of dependent cells. As such, it is a phenomenon which should be considered in studies of reversion frequency. To determine the rate at which cell types arise by reversion of a completely dependent parent, it is, of course, necessary to grow the dependent cells in the presence of the growth-factor they require. When the cells are then plated to a deficient medium in order to detect independent cell types, it is possible that partially reverted cells could not express themselves, due to their previous growth in the presence

of the growth-factor for which they have a partial requirement. It has been shown previously, in the case of the completely dependent glycineless mutant, that the reversion frequency apparently decreases with increasing amounts of growth prior to plating on minimal agar. This was not due to an accentuation of a lower growth-rate of the reverted as compared with the dependent type. It occurred because extensive growth in the presence of glycine has a depressing effect on the abilities of the reverted cells later to express themselves phenotypically when plated to minimal agar[3].

The phenomenon described may have implications in regard to problems of differentiation and abnormal growth, since it reveals a mechanism by which newly formed, faster-growing cells can be specifically suppressed by an excess of the metabolite required by the parental cell type. A discussion of the possible basis for this inhibition phenomenon is being given elsewhere[4].

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Mucus-producing Goblet Cells of the Small Intestine

IT is generally assumed that the intestinal epithelium is formed in the crypts of Lieberkühn. From this region of numerous mitoses the cells are presumed to move up towards the summit of the villi[1] from which they are shed. The average time required for the cells to pass through this phase has been calculated to be 1·57 days in the duodenum and 1·35 days in the ileum of the white rat[2]. How, when and where the goblet cells evacuate their mucus is not definitely known.

In order to answer this question I have endeavoured to make an evaluation of the intact cells. In ordinary histological sections it is impossible to account for all the mucous cells. By utilizing a method based on the preparation of intact villi and crypts by microdissection, staining the mucus of the goblet cells, and embedding in a suitably transparent medium, it is possible, however, to study the filling of intact cells with mucus and to determine their distribution in crypts and villi[3].

The experimental animals were cats, and the findings may be briefly summed up as follows: the goblet cells are most numerous near the bottom of the crypts; the number rapidly decreases towards their middle and remains nearly constant until the villus proper is reached. Here the density of goblet cells is practically constant upon the basal half, while a rapid decrease is evident towards the summit (see photomicrograph).

The cells contain small amounts of mucus near the bottom of the crypts. Then the mucus content rapidly increases and remains large all over the villus, except at the top, where the goblet cells are practically empty.

Intact villus from the small intestine of a cat. Staining: periodic acid, Schiff's method

These observations seem to indicate that the goblet cells are formed at the bottom of the crypts, where the quantity of mucus is scanty and the number of cells is large. Towards the middle of the crypts the goblet cells mature, and at the same time their number is considerably reduced. The decreasing density of the goblet cells in this region may be due to the mitotic activity of the intervening cells which push the goblet cells apart. In the cat, therefore, two generative zones exist overlapping each other only slightly: (1) deep in the crypts, there is a zone where goblet cells are generated; (2) higher up a zone of generation of columnar cells. From the crypts, the goblet cells move as components of the epithelial layer towards the summit of the villus, where they perish.

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Development of Intranuclear Inclusions in Virus-diseased Cells of Lepidopterous Larvæ

FOR some time now, Dr. K. M. Smith and I have been studying, in sections for the electron and light microscopes, the role of intranuclear nets which form in insect cells infected with nuclear polyhedral viruses[1], and we are accumulating more and more data indicating that the polyhedral and previrus materials may originate in these nets. One of the biggest difficulties has been the lack of adequate cytological techniques for critically recognizing and differentiating the various intranuclear particles, and their relations to each other. Recently, Mazia *et al.*[2] published a new cytochemical method for the study of proteins using bromophenol blue as the dye, and this method, together with appropriate pretreatments of Carnoy-fixed sections, has now been used along

with other methods to study the intranuclear cytology of infected cells.

Aqueous or alcoholic solutions of bromophenol blue, with or without mercuric chloride, did not stain nuclear polyhedra, in spite of the fact that they are among the most proteinaceous of all cell particles known, and though their protein is not bound to nucleic acids. This resistance to staining is paralleled by their failure to take acidic stains, for example, with Giemsa staining. After ten minutes of pretreatment in normal hydrochloric acid at 60° C., however, the polyhedra were stained intensely with bromophenol blue (with or without mercuric chloride), and perhaps more intensely than even the cross-striations of the striated muscle fibres. After the same pretreatment the polyhedra also stained, pink, with dilute Giemsa solution.

The intranuclear changes of virus-infected cells of the larvæ of several species of Lepidoptera have now been examined, and minor differences have been found between the species. Here only an outline of the main features of the sequence of intranuclear changes need be given. The nucleus of an infected cell enlarges enormously, and most of the chromatin material clumps together to form an off-central oval chromatic mass. This mass, like the chromatin material from which it is derived, stains moderately with bromophenol blue both with and without hydrochloric acid pretreatment. It is also strongly Feulgen-positive, as are many granules which develop in it. The chromatic mass later transforms into a network the non-refractile pores of which fail to stain, as also does the non-refractile nuclear sap. At about this time the nuclear mass or net reaches its maximum staining capacity with bromophenol blue, and after hydrochloric acid treatment may become as intensely stained as polyhedra. The increase of staining is evidenced not only in hydrochloric acid treated material but also in untreated material, though here the increase of coloration is not so marked. This tense staining capacity is not always afterwards maintained by the strands of the net.

At about the time of the transformation of the chromatin mass to a network, a great number of propolyhedra appear for the first time in the nucleus. They first appear outside the chromatic mass or network and not in the pores of the latter, though on occasion polyhedra may also develop within larger pores of the network and afterwards continue to develop there. The smallest of the propolyhedra observed are about 0·2–0·3 μ in diameter, and are found around the network and at the periphery of the nucleus. Like the mature polyhedra, they stain intensely with bromophenol blue after hydrochloric acid pretreatment. They grow into mature polyhedra, 1½ μ or more in diameter, by which time they pack the nucleus. It may be mentioned here that the earliest propolyhedra are smaller in diameter than the length of the mature virus rods found in the larger polyhedra. Only very rarely, and then most often in the very largest nuclei, were small propolyhedra seen in nuclei together with enlarged polyhedra 0·7 μ or more in diameter. In nuclei with enlarged polyhedra, the latter were all much the same size, for example, either all about 0·7 μ or 1 μ, etc. The evidence showed that in these species polyhedron formation is a relatively abrupt process, in which practically the entire complement of polyhedra is first formed, with each polyhedron afterwards growing in size in step with its neighbours. It is not precluded, however, that in other species or conditions the smallest propolyhedra formed may be somewhat larger than 0·2 μ in diameter, that propolyhedral formation may be a more continuous process, or that the propolyhedra arise in even more intimate connexion with the chromatic masses or nets than in the material described here.

As the polyhedra grow and begin to pack the nucleus, the nuclear net undergoes further changes. It may expand to embrace a much greater volume of the nucleus and secondarily enclose many polyhedra in its enlarged pores. At this stage pieces may become detached from the main body of the net, and a visible diffusion of Feulgen-positive material away from its remaining strands may occur, as its staining capacity for bromophenol blue also decreases. Alternatively, the pore contents of the net may transform into a mass of highly refractile non-staining globules, the Feulgen and bromophenol blue positive materials of the strands being dissipated in the process. The former process was more common in one species; the latter in another.

Several cytoplasmic polyhedroses of the midgut have also been examined with bromophenol blue techniques. In these cases, unlike what happens in the nuclear polyhedroses studied, the formation of polyhedra was a very prolonged and continuous process in any cell, those forming and maturing first arising apically, and the latter ones forming more basally. The minimal observed size of the polyhedra is here also about 0·2 μ in diameter. In one of the species examined the cytoplasmic polyhedra stained with bromophenol blue even without hydrochloric acid pretreatment. In another the hydrochloric acid pretreatment was necessary for staining, as for the nuclear polyhedroses examined. The formation of cytoplasmic polyhedra in the small basal cells of the midgut appears to be a relatively abrupt process, as with the nuclear polyhedra.

After hydrochloric acid pretreatment, the bromophenol blue technique has also been found to stain intensely the crystalline cytoplasmic inclusions of plant cells infected with tobacco mosaic virus. The method would probably prove of value also in the study of virus-diseased vertebrate cells and bacteria.

Cytological and cytochemical studies of the various polyhedroses are continuing and will be published in detail elsewhere.

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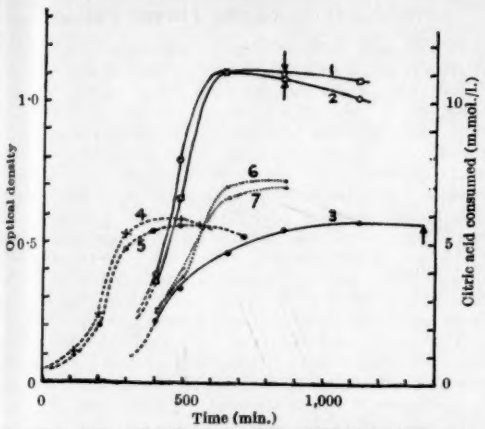
Effect of Citric Acid on the Growth of a Variant of *Bacillus subtilis*

The role of the tricarboxylic acid cycle in the metabolism of micro-organisms has been investigated by many authors with contradictory results, and the question has been recently reviewed by Krebs[1]. This author, working with yeast, concluded that the reactions of the tricarboxylic acid cycle are primarily concerned with the supply of metabolic intermediates rather than of energy.

Experimental support for this conclusion is given by the present investigation. It is shown that citric acid, without actively participating in respiration, may be very effective in the nitrogen metabolism of



Curves 1, 2, 3. Growth curves of *B. subtilis* M_2^- at 35° on a medium containing *M*/10 glycerol, mineral salt (ref. 4) without ammonium salt and supplemented with: (1) □—□—□—, *M*/200 glutamic acid, *M*/200 citric acid, *M*/50 ammonium sulphate; (2) O—O—O, *M*/200 glutamic acid and *M*/200 citric acid; (3) ●—●—●, *M*/200 glutamic acid
Curves 4, 5. Growth curve of *B. subtilis* S_1^- in the same basal medium supplemented with: (4) +..+..+.., *M*/500 glutamic acid; (5) ●..●..●, *M*/500 glutamic acid and *M*/250 citric acid.
Curves 6, 7. Consumption of citric acid in m*M*/litre, in the two cultures related respectively to curves 2 and 1

a variant (M_2^-) of *B. subtilis*. We have previously shown[2] that a strain, S_1^-, can grow on glycerol (*M*/10) as carbon and energy source, and glutamate (*M*/200) as the nitrogen nutrient. The ammonium salt present in the medium is without influence and the glutamic acid is the limiting factor for the total growth; 90–100 per cent of the glutamic acid nitrogen is recovered in the bacteria at the stationary phase. With the variant M_2^-, the nitrogen balance after growth is very different (Table 1, see also graph); the total growth, expressed as bacterial nitrogen or optical density, is much smaller, the glutamate is still the limiting factor and disappears completely from the medium. The growth-rate is also much reduced, the generation-time being about 300 to 400 min. against 140 min. for the S_1^- strain. Citric acid (*M*/200 or *M*/50) enhances markedly the rate and the maximum growth of M_2^-; ammonium is without appreciable influence. On the contrary, the citric acid has a slightly inhibitory effect on a culture of S_1^-. The main difference between the S_1^- and M_2^- strains is the production of ammonium ions in the medium by the latter; this corresponds to a loss of glutamic acid, which is prevented by citric acid. Citric acid, estimated by the method of Ajl[3], is effectively utilized during growth (Table 1 and graph).

Table 1. Nitrogen Balance of Cultures of the *B. subtilis* Strain M_2^-

Additions to the medium	Nitrogen in bacteria	NH_4^+ in the medium after growth	Total nitrogen in the medium after growth	Nitrogen recovery	Citric acid consumption
Glut. acid 4·95	1·94	2·51	3·09	5·03	—
Glut. acid 4·95					
Citric acid 20·0	3·80	0·15	1·10	4·90	6·90
Glut. acid 4·95					
Citric acid 20·0	3·84	—	—	—	7·13
Ammon. sulph. 20·0					

A medium containing *M*/ 0 glycerol and the common salts (ref. 2) without ammonium ions (final *p*H 6·4) is supplemented with the substances listed in the first column. All values are expressed in m*M*/litre. The bacteria are collected at the time indicated by the arrow in the graph. The non-ammonium nitrogen in the medium at this time may arise from a partial lysis.

In contrast with the action of citric acid on growth, very little oxidation of this compound occurs. The oxidation of glycerol is not stimulated by citric acid (Table 2). These observations show clearly that citric acid takes part in the process of synthesis, but does not essentially supply energy for the process. It is also apparent that the main action is on the nitrogen economy. As the ammonium salt has no important influence on growth in presence of citric acid, this acid is not used for assimilation of ammonium ions, but probably as an acceptor of a part of the amide group of glutamic acid.

Table 2

Substrate	Qo_2	Qo_2 (endogenous oxidation neglected)
—	61·6	—
Glycerol	198·4	136·8
Citrate	80·4	18·8
Glycerol + citrate	206·8	145·2

Oxygen consumption in 1 hr. by 2 ml. of a suspension of washed bacteria in phosphate buffer *M*/20, *p*H 6·4. Optical density of the suspension, 2·68. Final concentration of substrate, 0·04 *M*.

All the members of the tricarboxylic acid cycle, or the substances which enter the cycle, act in the same way as citric acid (Table 3). The complete tricarboxylic acid cycle appears to be the basis of the main synthetic process in this micro-organism. Other experiments with the same organism[4], on transamination, support this view. This demonstration has been possible on account of the special metabolic behaviour of *B. subtilis*, in which glycerol, in spite of its role as source of energy and carbon, does not, in all probability, enter the tricarboxylic acid cycle.

Table 3

Additions to the medium	Growth
None	100
Citric acid	179
Malic acid	155
Fumaric acid	148
Pyruvic acid	136
Glucose	136
Lactic acid	136
α-Ketoglutaric acid	127
Succinic acid	126
Acetic acid	123
Ethanol acid	99
Tartaric acid	102
Butyric acid	103

Culture medium: *M*/10 glycerol, mineral salts and *M*/200 glutamic acid, at *p*H 6·4. All the additions are *M*/200, except glucose (*M*/400). The values of growth are the maximal values, which are reached after different times and compared with the growth without addition, taken as 100.

This work has been supported by the Institut de recherches scientifiques pour l'industrie et l'agriculture, the Institut Belge d'alimentation et de Nutrition and the Centre de Brasserie et Malterie.

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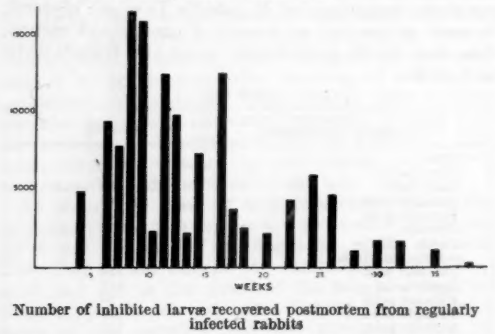
Phenomenon of Protection in Infections of *Trichostrongylus retortæformis*

Two preceding communications[1] discussed the phenomena of host resistance in infections of *Trichostrongylus retortæformis* in the rabbit. Two separate mechanisms were described, self-cure and the inhibition of larval development.

It now appears that there is a third mechanism of resistance which prevents infective larvæ from establishing themselves. In a series of recent experiments, rabbits were infected with *T. retortæformis* larvæ three times a week. For the first three weeks the doses of larvæ administered increased but thereafter they remained constant. The rabbits were now receiving the equivalent of a lethal dose each week. In spite of this, however, no effect was discernible on their health or live-weight gain.

Individual members of the group were killed at regular intervals, and it was found by the estimation of their worm burdens that the number of inhibited third-stage larvæ first rose for approximately eight weeks and then fell, the rate of fall decreasing meanwhile. This progressive diminution in the numbers of inhibited larvæ was very similar to that described in an earlier letter as occurring when a large number of larvæ become established in a previously infected animal as a result of the administration of a single dose. The fæcal egg-count of the regularly infected rabbits discussed in this communication also followed a similar course and showed the same periodicity as that which was previously seen following the administration of a single dose of larvæ.



Number of inhibited larvæ recovered postmortem from regularly infected rabbits

It appears therefore that, under the conditions of these experiments, after the eighth week, although infective larvæ were still being regularly administered, both the decrease in the number of inhibited larvæ and the course of the fæcal egg-count were similar to those encountered where larvæ have been established by a single dose. It appears, therefore, that the larvæ administered after the eighth week were unable to establish themselves and that the subsequent course of the infection refers entirely to the larvæ administered before that time.

Stoll, in 1929, reported that lambs exposed to repeated infection with *Hæmonchus contortus* were able to throw off the worms and thereafter were refractory to re-infection. These phenomena he named self-cure and protection. It is suggested that the term 'protection' may correctly be used for this third mechanism of resistance to *T. retortæformis*.

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'Rabbit-Gait' in the House Mouse

In October 1952, during the classification of mice from a *fused* (*Fu*) stock, a mouse was observed with a gait closely resembling that of a rabbit. Since then, from two other matings in the same stock, four more animals behaving in a similar way have appeared. The five mice, the parents of which walk and run normally, seem to fall into two distinct classes: (*a*) those which can only move their hind legs simultaneously, and (*b*) those which move their hind legs simultaneously when running but independently when walking; in every case movement of the front legs is normal. Class (*a*) has a *Fu*/+ female and a *Fu*/+, *T*/+ (*T* — *brachyury*) male, and class (*b*) has two females and a male all *Fu*/+, *T*/+.

The data suggest that the condition described above is determined genetically and is closely associated with *fused*. This hypothesis is now being tested and a fuller account of the work will be published later.

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Circulation in *Lacerta viridis*

Using radiological methods, Prakash[1] has recently investigated the mode of action of the heart of the lizard *Uromastix hardwicki* and has concluded that there is very considerable mixture of the blood from the two auricles in the partially divided ventricle.

At the same time we have been making a preliminary radiographic study of the heart and circulation of *Lacerta viridis*.

As is well known, in the lizards both auricles open to the dorsal side of the interventricular septum. Thus blood from the right auricle on its way to the right ventricle (cavum pulmonale) has to traverse a portion of the left ventricle. Under such conditions, it is most likely that some degree of mixture of the blood from the two auricles will take place. Again, it is well known that the right division of the ventricle is smaller than the left so that equal volumes of blood cannot possibly be pumped to general and pulmonary circulations at the same time, and we must conclude that some mixture in the ventricle is unavoidable. Nevertheless the preliminary experiments we have made lead us to the conclusion that a marked degree of separation of arterial and venous blood is achieved in *Lacerta viridis*.

In decerebrate lizards, injections of the radio-opaque medium 'thorotrast' have been made both through the posterior vena cava and through the pulmonary vein. In posterior vena cava injections the thorotrast is seen to pass through the heart into the pulmonary arteries, and in the few experiments so far made the 'dye' cannot be seen in the carotid vessels or right systemic arch. There is a slight element of doubt as to whether in one instance 'dye' can be seen in the left systemic. On the other hand, 'dye' injected into the left auricle by way of one of the pulmonary veins is clearly seen to emerge in the carotids and both systemic arches. No sign of it has been seen in the pulmonary arteries.

It is proposed to continue and extend these studies; but in the meantime it seems desirable to record that

the very considerable mixture of blood in the ventricle found by Prakash[1] in *Uromastix hardwicki* is not found in *Lacerta viridis*.

Attention must also be directed to the fact that the results so far obtained tend to support the views of von Hofsten[2] concerning the nature of the blood conveyed by the left systemic arch in reptiles. Von Hofsten maintains that in Lepidosauria during ventricular systole the free edge of the interventricular septum tends to complete the division of the ventricle in such a way that the opening of the left systemic arch lies alongside that of the right in the cavum arteriosum (left ventricular cavity) and that therefore these two systemic vessels receive blood of the same degree of mixture. But in Chelonia, von Hofsten believes that the opening of the left systemic arch lies to the right of the free edge of the interventricular septum and so during systole will receive blood from the cavum pulmonale. On this latter point we can express no opinion at present; but the results outlined above lead us to believe that in *Lacerta viridis* there is no marked difference in the type of blood conveyed by left and right systemic arches.

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Intersexuality in *Asellus aquaticus* L. parasitized by a Larval Acanthocephalan

Intersexes in *Asellus aquaticus* L., in which the anterior abdominal appendages are intermediate in form between the male and female condition, have been recorded from time to time and their occurrence has been reviewed by Maercks[1]. They were always females, 5–8 mm. in length. Needham[2] has pointed out that their anterior pleopods, which were never completely male in form, correspond to various stages in the normal development of the male organs.

Collections of *A. aquaticus* from two sources in Perthshire have yielded 80 individuals, approximately 1·5 per cent of the total collections, parasitized by a larval polymorphid. Of these parasitized individuals, 39 appeared to be normal males of 3–8 mm. and 13 normal females of 3·25–7 mm. The remainder, 28 individuals of 5–8·5 mm., showed various degrees of intersexuality. More than 90 per cent of those parasitized were noticeably darker than normal.

All the females and the intersexes had unexpanded oostegites typical of the immature or non-breeding female. The second pleopods of the intersexes were at different stages of development similar to those described by Needham[3] in the normal development of the male. In those individuals in which the development of the second pleopods was well advanced, first pleopods of male form were present. Where both first and second pleopods were almost completely male, copulatory styles were sometimes present. In some cases, development of the second pleopods was more advanced on one side than on the other.

Like those described by Maercks[1], these intersexes would seem to be modified females, since it is possible to arrange them in such a way that their anterior pleopods present a series similar to that seen in the normal development of the male. Further, three females and one intersex showed a change in a male direction after being brought into the laboratory. Two of these females developed first pleopods while under observation, confirming Needham's[3] assertion, on embryological grounds, that it is the first pair of pleopods which is absent in female *Asellus*.

These intersexes differed from those described by Maercks[1] in that copulatory styles were never present unless both first and second pleopods were almost completely male, whereas in his specimens copulatory styles were always present although the first pleopods might be absent and the second only slightly male. Unlike his intersexes, they have not been found carrying eggs or with expanded oostegites although collected together with many breeding females.

The fact that all the parasitized females and intersexes had immature oostegites is similar to the observations of Le Roux[4] on the state of oostegites in *Gammarus pulex* (L.) parasitized by the larvæ of the acanthocephalan *Polymorphus minutus* (Goeze). It has been shown experimentally by Le Roux[5] for *Gammarus* and by Haemmerli-Boveri[6] for *Asellus* that the development of the oostegites is correlated with ovarian activity.

Although in the present instance no intersexes have been found among more than 3,500 unparasitized *Asellus*, it is not suggested here that intersexuality only occurs in parasitized individuals. Maercks[1] sectioned his specimens so that any parasites present would have been seen.

It is hoped to carry out further work on the relationship between intersexuality and parasitization in *Asellus*.

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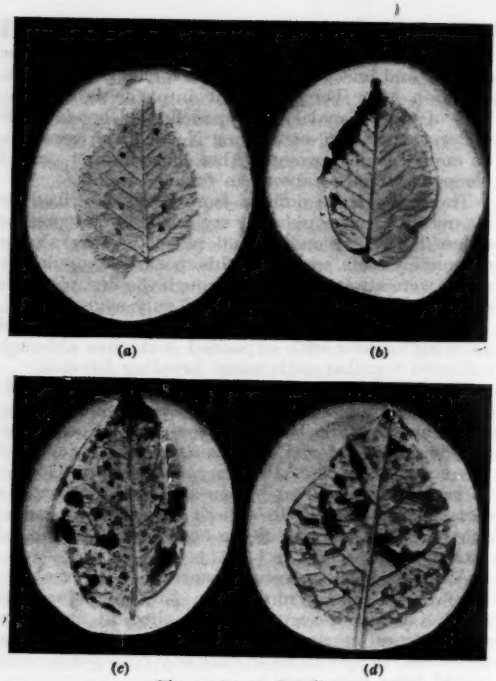
Distribution of Copper Fungicide Deposits on Plant Surfaces

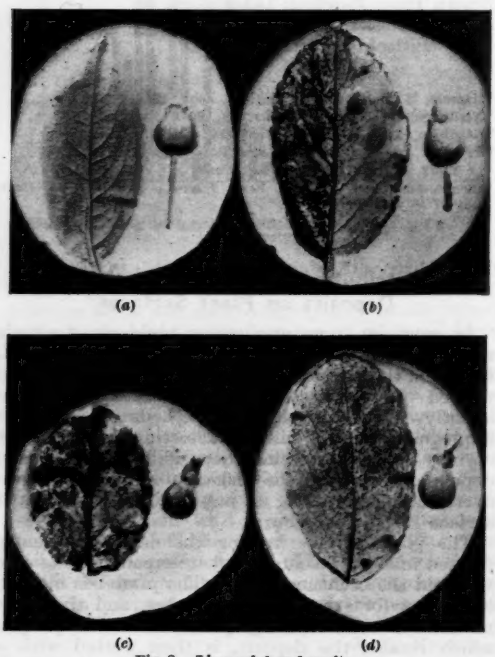
In work on spray application problems, a simple method has been devised, capable of use in the field, by which the pattern of copper fungicide deposits on treated plant surfaces may be assessed and permanently recorded. Earlier methods using paper impregnated with a suitable detecting agent are not entirely satisfactory, since deposits accumulating in depressions may not be picked up. This has been overcome by preparing an impression of the treated surface in plaster-of-Paris.

The plant surface holding the deposit is gently pressed into the calcium sulphate cream, taking care to avoid the occlusion of air. The plaster is allowed to harden for some twenty minutes, and the plant material is then carefully peeled off. The plaque, which retains the deposit, is then wetted with a 0·2 per cent aqueous solution of sodium diethyldithiocarbamate, when the imprint of the distribution of the fungicide develops. An approximate quantita-



(a) (b) (c) (d)

Fig. 1. Copper deposits.
(a) Placed droplets of copper oxychloride suspension (0·2 per cent copper) on potato leaf, under surface. (b) Copper oxychloride suspension (0·2 per cent copper) deposit on potato leaf, upper surface, after field application. (c) As (b), and (d) as (b), under surfaces



(a) (b) (c) (d)

Fig. 2. Lime sulphur deposits.
(a) Apple leaf (under surface) and fruitlet unsprayed. (b) Lime sulphur (1 per cent) deposit on apple leaf (under surface) and fruitlet, after field application. (c) As (b), upper surface of leaf. (d) As (c), with added wetter

tive assessment of distribution may be made by comparison of the intensity of coloration at different points of the plaque with that from standardized droplets of the same fungicide upon the same plant surface.

The plaster technique has also been used for lime sulphur deposits. Here the cream is made with 0·5 per cent silver nitrate solution, and, after removal of the plant material, the plaque is immersed in a fixing solution of sodium thiosulphate and potassium metabisulphite and well washed in running water. We have also adapted the thallium test described by Feigl[1] for the detection of the deposit on the plaque.

We have used the plaster method successfully to record the levels and distribution, following different treatments, of copper deposits on bean, potato, tomato and banana leaves and of lime sulphur deposits on apple leaves and fruitlets. Typical plaques are shown in Figs. 1 and 2. The technique may prove particularly useful in studying copper application problems in tropical areas where loss and redistribution of deposits by rainfall are important considerations.

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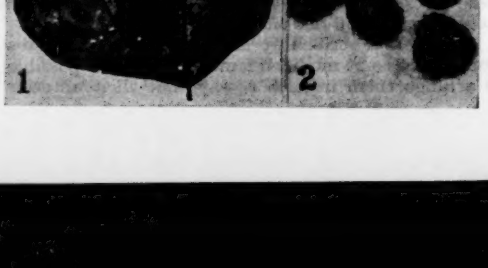
Angular Black Spot Disease of Mung Beans

Severe leaf spot disease on mung bean (*Phaseolus radiatus* L.) was observed near Banaras, India, during the months of September and October when the plants were just reaching maturity. The infection spots appeared mostly on lower leaves and could be easily mistaken on the basis of field symptoms for *Cercospora cruenta* occurring on the same host. Infection spots first appear as pale green angular spots, gradually deepening in colour, finally turning purplish-black to opaque (Fig. 1). The spots are usually 4–6 mm. × 3–6 mm., often coalescing to form patches. There was no indication of the diseased leaves showing premature drying up.

Detailed microscopic examination of the diseased parts indicated that the disease was incited by a species of *Protomycopsis*. The mycelium is inter-



cellular, septate, branched, developing numerous dark reddish-brown resting spores. Young spores are at first thin-walled, hyaline and pyriform, and turn deep brown and warty as they mature. The mature spores are reddish-brown, globose-oval, thick-walled, covered with pyramidal warts, measuring 22·5–32·5 μ (Fig. 2). Studies on germination of resting spores and other cultural studies are in progress.

As regards the identity of the pathogen, the fungus is a species of *Protomycopsis*, which is indicated by the warty nature of its exospore and other characters. *Synchytrium phaseoli* Patel, Kulkarni and Dhande was reported from Jalagaon, Bombay State, by Patel *et al.*[1], as inciting leaf spots on mung beans. A portion of the type material was examined by us through the kindness of Dr. M. K. Patel. The results suggest that the fungus reported as *S. phaseoli* is identical with the fungus found by us. The intercellular hyphæ and resting spores distributed in the spaces indicate that it bears no relation to *Synchytrium*. The name *Synchytrium phaseoli* Weston precedes *S. phaseoli* Patel *et al.*, consequently the *Protomycopsis* species under study is designated *P. patelii* Pavgi and Thirumalachar *nom. nov.* in honour of Dr. M. K. Patel, who has contributed greatly to our knowledge of Indian fungi.

A detailed account will be published elsewhere.

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Preservation of the Virus of Tomato Spotted Wilt in Dried Plant Material

It is difficult to obtain accurate information about the properties of viruses which lose their infectivity *in vitro* too quickly. Tomato spotted wilt virus is one of these, and investigations on it are further limited by the fact that it is inactivated at comparatively low temperatures (35° C.). The *in vitro* life of tomato spotted wilt virus was reported by Bald and Samuel[1] to be about four hours in undiluted expressed juice held at room temperature. Subsequent work by Best and Samuel[2] and by Best[3] showed that the factors causing inactivation were the *p*H value of the juice and a tyrosinase catalysed oxidation, and that by controlling the *p*H value and redox potential of the medium[4] the virus could be maintained infective in solution for thirty-five days at 2° C.

Slow drying of infective plant tissue near the freezing point was not successful.

Transferring freshly harvested infective material to a 'deep-freeze' at — 20° C. met with partial success: strain[5] *A* survived for thirty-two days but not for seventy-four days, and strain *E* remained infective for thirty-six days but not for seventy-eight days.

The most successful method yet tried is to freeze-dry tissue and store it at a low temperature. Tomato leaflets infected with strain *A* and tissue of *N. glutinosa* infected with strain *E* were put into a deep freeze at — 20° C. as soon as they were harvested. Within two hours the leaves were removed, cut as quickly as possible into pieces about 5 mm. square and put into a flask of a freeze dryer actuated by a high-vacuum pump and suitable refrigerants. The temperature in the bulb was about — 30° C. It took about eight hours to dry 11 gm. (fresh weight) of tomato leaflets. This operation was kindly performed for us by Mr. Zwar, of the Section of Plant Physiology of the Commonwealth Scientific and Industrial Research Organization. After eight hours, all but the last traces of water were removed and the material was transferred to screw-top bottles and stored (in the presence of air) in a deep-freeze at — 20° C. After 36, 82 and 125 days of storage, portions of each sample were withdrawn suspended in buffer solution of *p*H 7·5 made 0·01 molar in respect to sodium sulphite. Inocula prepared in this way were inoculated on to plants of tomato, tobacco and *N. glutinosa* by methods described in our previous papers. After storage for thirty-six and for eighty-two days, all inoculated plants became infected with the virus. The reaction of plants inoculated 125 days after harvesting showed that both strain *A* and strain *E* of tomato spotted wilt virus had survived; but there was some evidence that the mild strain *E* is not holding out as well as strain *A*.

The tests are still in progress.

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Causes of Coconut Nutfall and Gumosis

Way[1] has reported that the coreid bug *Theraptus* sp. is the cause of nutfall and gumosis of coconuts in East Africa. During more recent investigations to discover economical methods of combating this pest, it has been found that *Theraptus* sp. is only one of at least four insect pests causing either nutfall or gumosis or both. The larvæ of the weevil *Diocalandra frumenti* F. will cause both nutfall and particularly gumosis of immature nuts. Mansfield-Aders[2] noted the presence of *D. frumenti* in coconuts in Zanzibar and suggested that it might be a cause of nutfall and gumosis. *D. frumenti* thrives best in areas infested by *Theraptus* sp. and *Anoplolepis longipes* Jerd. It is preyed upon by both *Anoplolepis custodiens* Smith and *Œcophylla smaragdina* L., var. *longinoda* Latr. The larvæ of the moth *Lamoria* sp. cause considerable nutfall in palms foraged by *A. longipes* and *Pheidole* sp. by boring into and eating the bases of the young nuts. A major cause of nutfall in areas where *Theraptus* sp., *D. frumenti* and *Lamoria* sp. have been either eradicated or controlled by insecticides is the ant *Polyrhacis schistacea* Gerst., vars. *rugulosa* Mayr and *militaris* F. These ants nest both in the ground and in the palms, and feed mostly on pollen and nectar. They are so efficient at removing the nectar from flowering nuts that they remove the lining of the stigmata and prevent fertilization. In palms heavily foraged by *Polyrhacis* sp. complete loss of nuts occurs.

Theraptus sp. *D. frumenti* and the larvæ of *Lamoria* sp. are all very resistant to DDT, whether used as a wettable powder or dissolved in oils. However, the addition of coumarone resin[3] renders the same formulations highly toxic and persistent. To prevent *Pheidole* sp. foraging in palms, a 10 per cent DDT (80 per cent *para para*) with 1 per cent coumarone indene resin (grade C.469 from the British Resin Products, Ltd.) dissolved in power kerosene is effective. This spray is persistent for at least three months when used in the crowns of the palms, and for five months when applied around the trunks of the palms. It has little effect on the larger species of ants such as *Œcophylla smaragdina*, *Anoplolepis custodiens* and *Polyrhacis* sp. *Polyrhacis* sp. can be controlled by spraying the trunks with 'Dieldrex'. The addition of 1 per cent coumarone indene resin to 10 per cent 'Dieldrex' prevents it being washed off the trunks by rain and at least doubles its persistence.

Theraptus sp. has been successfully eradicated from Prison Island, which had 168 heavily infested palms, with one spraying of 3 per cent DDT plus 0·3 per cent resin. By using 'Eclipse' pneumatic sprayers, all the palms were hand-sprayed in one day. So far as is known, *Theraptus* sp. has no wild host plants; it has been found only on mangoes, guavas, cinnamon, cacao and coconuts. It feeds only on the fruits of these plants, which often fall off after developing necrotic lesions. In the laboratory it has been very successfully reared on French beans (*Vigna* sp.).

Large-scale control is now being attempted by drift-mist spraying using a 'Micron' sprayer, which in still air will throw a mist up to 70 ft.

Fuller reports on these coconut problems will be published elsewhere. I wish to thank Mr. A. K. Briant, the director of agriculture, for permission to publish this note, and Dr. W. J. Hall, of the Commonwealth Institute of Entomology, for the insect identifications.

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Resistance to a Plant Disease associated with High Glucose Content of Leaf

Knight and Clouston[1], and Knight[2], in a series of papers from 1939 onwards, have worked out the genetics of the resistance of cotton to the blackarm disease (*Xanthomonas malvacearum*) and have succeeded in transferring resistance from New World to Egyptian (Sakel) types.

Clouston has found (private communication from Dr. R. L. Knight) that leaf extracts of blackarm-resistant cottons had a stronger reducing action on Fehling solution and considered that this might be associated with the mechanism of blackarm resistance.

We have confirmed this for synthesized varieties containing the blackarm resistance genes B_2 and $B_3 + B_3$, compared with their susceptible parent type. In addition, by the use of a quantitative paper-chromatography technique[3], it appears that this stronger reducing action of a water extract of the dried material may be attributed to a significantly higher glucose-level in the leaf, which is present from the cotyledonary stage onwards, in plants from different plots, sampled at different times of the day. The resistant seed contains higher sucrose and raffinose (the only two sugars found present), and possibly more oil, although this has not been sufficiently confirmed. The phosphate content, as measured colorimetrically on a 2 per cent acetic acid extract[4], is also generally, but not always, higher in the resistant leaf.

The leaf glucose-level in the susceptible plants, which is very low at the beginning of the season, appears to rise steadily with time, while that of the resistant remains consistently high. Three months from sowing, the glucose-level in the susceptible plants appears almost as high as in the resistant planted at the same time.

While no inhibition of the local strains of *Xanthomonas malvacearum* on nutrient agar has been observed here with additions of glucose up to 10 per cent w/v, one case[5] has been quoted where additions of both glucose and phosphate have inhibited growth, but only after sterilization at high temperatures.

It seems certain that resistance does not reside in the glucose itself, but in some factor which gives rise early to a high glucose content. The problem is still under investigation.

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Growth Response of Tree Seedlings to Mycorrhizal Mycelia in the Absence of a Mycorrhizal Association

Mycelium known to produce ectotrophic mycorrhizas can stimulate the growth of an endotrophic tree species although it does not form an association with the roots. This was demonstrated in pot-culture experiments in which seedlings of Lawson cypress (*Chamæcyparis lawsoniana* Parl.) were raised in soil inoculated with *Rhizopogon luteolus* Fr.

A poor heathland soil free from the mycelium of *Rh. luteolus* and from a mycorrhizal associate of Lawson cypress was used as potting medium. Sterilized soil which one would regard as the ideal substrate for inoculation experiments did not prove suitable as it produced relatively good control plants, thus not allowing for a full demonstration of the growth response to the inoculum. Furthermore, the activity of the ectotrophic mycelium was observed to be less vigorous in the sterilized than in the unsterilized soil.

Rhizopogon luteolus was inoculated in the form of mycorrhizal roots of Scots pine. This method was used in preference to introduction of mycelium from pure culture, as results of earlier experiments had shown that mycorrhizal material was more effective

Seedlings of Lawson cypress (*Chamæcyparis lawsoniana* Parl.) in their second growing season: (*A*) control soil, not inoculated; (1*A*) soil inoculated with mycorrhizal pine roots; (2*A*) soil inoculated with non-mycorrhizal pine roots

than a mycelial inoculum. Before introduction into the soil, the mycorrhizas were surface-sterilized with mercuric chloride.

Among the various kinds of controls employed in the experiment were cultures inoculated with non-mycorrhizal roots of pine and some with fully sterilized pine mycorrhizas.

At the end of the first season of growth, marked stimulation of root and shoot development took place in the Lawson cypress cultures that had been inoculated with active mycorrhizal roots. The accompanying photograph illustrates the improvement in growth of the 'treated' plants (1*A*) as compared with absolute controls, not inoculated (*A*) and controls inoculated with non-mycorrhizal pine roots (2*A*). (No root infection was observed in the stimulated seedlings or in the control plants, confirming that the cultures had been kept free from soil contamination.)

Employing the method of root inoculation, further experiments are in progress to test and analyse the effect produced by ectotrophic mycelia on endotrophic tree species.

So far, no instance of the converse relationship, the influence of an endotrophic mycelium on an ectotrophic species, has been recorded.

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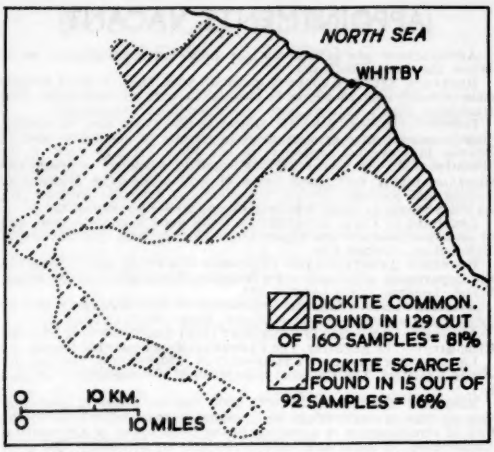
Distribution of Dickite in some British Sandstones

SAMPLES of sandstone containing well-crystallized material belonging to the kaolin group of minerals have been collected and examined microscopically (by F. S.). In thin sections of the rocks the mineral appears prismatic or vermicular with pronounced transverse cleavage. The powder obtained by gently crushing the rock and sieving shows prismatic grains and hexagonal plates between 5 and 50 microns in diameter. Material having this appearance occurs in: (1) Lower Carboniferous sandstones from Anglesey and Caernarvonshire, (2) Millstone Grit from Anglesey, Staffordshire and Yorkshire, and (3) Middle Jurassic sandstones from Yorkshire. Although concentrations have been observed in cavities of fossil plants, the mineral occurs for the most part as a finely disseminated constituent of the rock, amounting to as much as 5 or 10 per cent by weight and having considerable vertical extent over wide areas.

Six specially pure separations were made for examination by X-ray diffraction methods (undertaken by G. B.). Powders from Lower Carboniferous sandstone near Bangor, Caernarvonshire, and from Millstone Grit, Bodorgan, Anglesey, both proved to be dickite with some quartz. Four separations from Yorkshire samples (Millstone Grit from Ellingstring and Middle Jurassic sandstones from the Whitby, Farndale and Bransdale districts) were all found to be dickite with some quartz and felspar.


NORTH SEA
WHITBY
DICKITE COMMON. FOUND IN 129 OUT OF 160 SAMPLES = 81%
DICKITE SCARCE. FOUND IN 15 OUT OF 92 SAMPLES = 16%
10 KM.
10 MILES

Distribution of dickite (based on microscope examinations) in the Middle Jurassic sandstones of Yorkshire. Outcrop greatly simplified

Greenly[1] described the Anglesey occurrences as kaolinite, but this was before the division of this mineral into distinct species by X-ray methods[2]. Hemingway and Brindley[3] recorded dickite in cracks, septaria and fossil casts from the Middle Jurassic rocks of Yorkshire.

Where the clay mineral crystals are observed microscopically there is usually evidence of alteration of other minerals, for example, the progressive solution of some of the heavy minerals, particularly garnet, and the formation of one or more of the following: anatase, brookite, outgrowth on zircon, and outgrowth on tourmaline. An examination of some 250 sandstones from the Middle Jurassic of Yorkshire suggests that the clay mineral crystals are characteristic of that part of the outcrop (Fig. 1) where severe alteration of the heavy minerals has been attributed to prolonged diagenetic changes which took place while the deposits were deeply buried[4], and a similar explanation may be offered for the development and distribution of the clay mineral crystals.

More detailed accounts of the geological distribution and of the mineralogical properties of the material will, it is hoped, be published elsewhere.

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APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH STUDENT (physics graduate with first- or good second-class (special) honours degree in physics) to work on ultrasonics—The Registrar, King's College, Newcastle-upon-Tyne (August 24).

DEPUTY (Principal Scientific Officer Grade) (with first- or second-class honours degree or equivalent in physics or chemistry, and an interest in biological problems) in the Field Trials Section of the Ministry of Supply Research Establishment, Salisbury, to design and supervise highly specialized forms of field trials—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A200/53A. (August 29).

LECTURER IN CIVIL ENGINEERING (with good honours degree, and at least two years practical experience)—The Registrar, The University, Nottingham (August 29).

RESEARCH ASSISTANT (with experience of work in microbiology) in the Department of Botany—The Secretary, University College, Gower Street, London, W.C.1 (August 29).

ASSISTANT LECTURER in the Department of Pure Mathematics—The Registrar, University College of Wales, Aberystwyth (August 31).

ASSISTANT LECTURERS IN CHEMISTRY (with qualifications in Physical Chemistry)—The Registrar, The University, Manchester 13 (August 31).

LEVERHULME RESEARCH FELLOWSHIP IN ENGINEERING PRODUCTION—The Registrar, The University, Edgbaston, Birmingham 15 (August 31).

RESEARCH ASSISTANTS (2), (with good honours degree in mathematics, physics or engineering, and preferably some experience in the field of aerodynamics or acoustics) in the Department of Aeronautical Engineering, to assist and initiate research on turbulence, jet noise and ground silencing devices—The Secretary and Registrar, The University, Southampton (August 31).

PRINCIPAL SCIENTIFIC OFFICER (with first- or second-class honours degree or equivalent in physics, and several years relevant postgraduate experience) at the Ministry of Supply Experimental Flying Establishment, Salisbury, to lead a section responsible for the complete design and proving of aircraft test instruments; to initiate methods of measurement of any physical quantity in test aircraft; to guide the aircraft industry in methods of maintenance and calibration of instruments used in test flying—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4236/53 (September 3).

LECTURER IN BACTERIOLOGY—The Secretary, The University, Edinburgh (September 5).

LECTURER IN ENGINEERING—The Secretary, The University, Aberdeen (September 5).

SENIOR SCIENTIFIC OFFICER (with good honours degree in botany or agricultural botany, and research experience in genetics and/or plant breeding) and a SCIENTIFIC OFFICER (with good honours degree in botany or agricultural botany) IN THE GRASS BREEDING SECTION—The Registrar, Welsh Plant Breeding Station, University College of Wales, Aberystwyth (September 5).

GRADUATE IN BIOCHEMISTRY OR CHEMISTRY (preferably of Ph.D. standard) to work on problems associated with the sprue syndrome and other nutritional disorders—Prof. A. C. Frazer, Department of Pharmacology, Medical School, Birmingham, 15 (September 12).

ASSISTANT LECTURER (with special interests in research into child psychology) in the Department of Psychology, and a RESEARCH ASSISTANT to carry out experimental work under the Professor of Psychology—The Registrar, The University, Manchester, 13 (September 15).

FERNEY CHAIR OF METALLURGY—The Registrar, The University, Edgbaston, Birmingham 15 (September 30).

MCROBERT RESEARCH FELLOWSHIP to undertake research relating to any disease that is generally regarded as malignant or incurable in any one of the following fields selected by the candidate and approved by the University: Bacteriology, Biology, Chemistry, Chemo-Therapy, Clinical Science, Endocrinology, Pathology or Physics—The Secretary, The University, Aberdeen (September 30).

SENIOR LECTURER IN THE DEPARTMENT OF PSYCHOLOGY, University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 30).

BIOCHEMIST to work on enzyme adaptation and related problems—Prof. John Yudkin, Queen Elizabeth College, Campden Hill Road, London, W.8.

CHEMIST (Senior Scientific Officer Grade) to lead small team engaged in the study of organic tannins (natural and synthetic) from the fundamental and technological standpoints; a CHEMIST (Senior Scientific Officer Grade) to be analyst for the Liaison Department; and a PHYSICS GRADUATE (Scientific Officer Grade) to study the physical properties of leather—The Director of Research, The British Leather Manufacturers Research Association, Milton Park, Egham, Surrey.

HONOURS GRADUATE (with experience in use of infra-red spectrophotometer) to assist in programme of research on various substances isolated from dairy products—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 53/14.

METALLURGISTS (with degree in Metallurgy, or A.I.M. or equivalent qualifications) in the Ministry of Supply at Aldermaston, Berks, to assist processing radio-active metals—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.76/53A.

PHYSICIST OR RESEARCH ENGINEER (with first- or second-class honours degree and research experience, preferably in textiles, plastics, or similar materials) to carry out basic research on the mechanical properties of fabrics—The Director of Research, The British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester 20.

PROFESSOR OF GEOGRAPHY—Dr. A. A. Duri, Dean, College of Arts and Science, Baghdad, Iraq.

SENIOR EXPERIMENTAL OFFICER (with at least H.S.C. (Science) or equivalent, but degree or H.N.C. may be an advantage) in the Electronics Division of the Atomic Energy Research Establishment, Harwell, to take charge of small section responsible for design and construction of small electro-mechanical mechanisms—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.302/53A.

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER (with first- or second-class honours degree in physical chemistry and postgraduate experience in physico-chemical research, and preferably with specialized knowledge in the field of high polymers) in the Department of Scientific and Industrial Research, Chemical Research Laboratory, Teddington—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.368/53A.

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